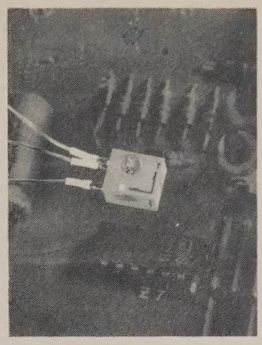
ENDEVCO

INSTRUCTION MANUAL

FOR MODEL 4476.2A

AMPLIFIED BRIDGE CONDITIONER

MODE CARD



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MODE CARD

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TABLE OF CONTENTS

		Page
1.0	GENERAL DESCRIPTION	
1.1	Introduction	1
1.2	Identification	1
1.3	Input Devices	1
1.4	Output Devices	2
2.0	PHYSICAL DESCRIPTION	
2.1	Mode Card	2
2.2	Front Panel Controls	2
2.3	Resistors	3
3.0	THEORY OF OPERATION	
3.1	Power	3
3.2	Excitation Regulator	3
3.3	Sensing	4
3.4	Bridge Completion	4
3.5	Balance Limiting	4
3.6	Amplifier	5
3.7	Zero Calibration	6
3.8	Calibration	6
4.0	OPERATING INSTRUCTIONS	
4.1	Transducer Connections	7
4.2	Sensing	7
4.3	Transducer Excitation Voltage	7
4.4	Bridge Completion Resistors	8
4.5	Calibration Resistors	8
4.6	Low Pass Filter	8
4.7	Measuring Acceleration, Force, etc.	9

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2/76

TABLE OF CONTENTS (Continued)

		Page
5.0	INITIAL SETUP AND CHECKOUT	
5.1	Unpacking and Inspection	10
5.2	Checkout Procedure	10
5.3	Excitation Regulator Voltage	12
5.4	Amplifier Zero	12
5.5	Residual Noise	13
5.6	Gain Accuracy	13
5.7	Gain Vernier Range	14
6.0	MAINTENANCE AND TROUBLESHOOTING	
6.1	Maintenace	14
6.2	Troubleshooting and Adjustments	14
6.3	Gain Adjustment	15
6.4	Common Mode Adjustment	16
6.5	Output DC Offset Adjustment	16
6.6	Factory Repairs	17
	WIRING DIAGRAMS	18-22

INSTRUCTION MANUAL
FOR MODEL 4476.2A
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1.0 GENERAL DESCRIPTION

1.1 Introduction

The Model 4476.2A Mode Card is designed to operate with the Model 4470 Universal Signal Conditioning Module. When plugged into the module, it provides adjustable and programmable excitation voltage, signal conditioning, filtering and amplification for resistive transducers and strain Gages.

The card is intended for use with 1, 2, or 4 active arm resistive elements connected in a bridge configuration and may be used with 2 to 9 wire systems.

Terminals are provided on the Mode Card to mount resistors for single shunt (bipolar) calibration, voltage programming (0 to 15 V dc) and bridge completion. External sensing and shunt calibration can be accomplished by removing appropriate jumpers.

1.2 Identification

Because the resistors mounted on the mode card are normally selected for a specific transducer, the card is usually associated with only one transducer. An identification label is mounted on the right side of the card handle with spaces provided for entering the transducer model number, serial number, and sensitivity. The mode card should be labeled at the time the resistors are installed.

1.3 Input Devices

The amplifier on the mode card has a differential input. The input is restricted to the use of resistive devices with less than 4000 ohm source resistance between the differential input terminals. The source transducer should be insulated from ground.

Because this mode card provides only shunt calibration, it is not recommended for use with piezoresistive transducers unless they are designed for shunt calibration. The Model 4476.1 Mode Card is suggested for any Endevco® piezoresistive transducer. When using piezoresistive transducers with the Model 4476.2A Mode Card, gains greater than 80 will magnify thermal zero shifts in the transducer and may result in data error.

1.4 Output Devices

The output is single ended and may be connected to any resistive load greater than 250 ohm. The circuit is stable with up to 10 μF of capacitive load. The amplifier will not be damaged by an accidental short circuit at the output. Maximum linear current capability is 20 mA. The output current will limit at approximately 50 mA.

2.0 PHYSICAL DESCRIPTION

2.1 Mode Card (See Drawing 4476.2A-1C)

The Mode Card is a printed circuit board on which are mounted integrated circuit amplifiers, a voltage post regulator, and bifurcated solder terminals for mounting bridge completion, calibration, programming resistors, and filter capacitors. The card is supplied without bridge completion or calibration resistors and filter capacitors unless otherwise specified on the order. Twenty-two gold plated contacts on each side of the board mate with a printed circuit receptacle in the 4470 module.

2.2 Front Panel Controls

2.2.1 Gain - The Gain control, S1 on the front panel of the mode card, is a six-position rotary switch which selects the voltage gain of the amplifier in steps, from 1 through 300. The steps are calibrated at the CCW position of the gain vernier.

2.2.2 Gain Vernier - The Vernier Gain control, R26 on the mode card, is a 15 turn screwdriver adjustable potentiometer which adjusts the voltage gain of the amplifier over the range of 1.0 to 3.5. Together with the Gain step switch, the Vernier Gain provides continuous adjustment of gain from 1.0 to 1,050.

2.2.3 Amplifier Zero - The Amplifier Zero control, R8 on the front panel of the mode card, is a 22 turn screwdriver adjustable potentiometer which adjusts the amplifier dc offset voltage due to input offset and bias currents. This voltage is adjustable over the range of ±5 mV referred to the input.

2.2.4 Excitation Adjust - The Excitation Adjust control, R56 on the front panel of the mode card, is a 15 turn potentiometer which adjusts the transducer excitation voltage. This voltage is adjustable from less than 100 mV to 15 V dc. To fix the excitation voltage at a constant magnitude, install Jumper F and a programming resistor R57.

2.2.5 Excitation Zero - The Excitation Zero control, S2 on the front panel of the mode card, is a pushbutton switch which reduces the excitation voltage to zero. The Zero pushbutton on the front panel of the 4470 is not operative when using this mode card.

2.3 Resistors

The Mode Card will accept resistors with maximum envelope dimensions of 1/4 x 3/8 inches (6.3 x 9.5 mm) at R1 through R4, 1/4 x 1/2 inches (6.3 x 12 mm) at R15 through R17 and 3/16 x 3/8 inches (4.7 x 9.5 mm) at R57. When resistors are requested for factory installation, the values and tolerances must be specified by the customer. MIL-R-93 Type RB-55 wire wound resistors will be supplied at R15 through R17, and RN55 or equal will be supplied at R1 through R4 when specified. At R57, 1/10 watt, 0.5% resistors are supplied when specified.

> CAUTION: After soldering resistors and/or jumpers on the mode card circuit board, turn the board over and resolder the bifurcated terminals to the printed circuit wiring. Heating only one side of these terminals may result in an intermittent contact. Always inspect both sides of the mode card after installation of resistors.

3.0 THEORY OF OPERATION

3.1 Power

Plus and minus 12 V dc power for the integrated circuit amplifiers and the post regulator is provided by the floating power supply in the Model 4470 Module. Resistor R59 sets the output of the supply to 24 Volts ±0.1 V dc. A common for the amplifier and signal output is established at the mid-point of the floating 20 Volt potential at the junction of R47 and R48, and at the output of Z6.

3.2 Excitation Regulator

The purpose of the post regulator circuit is to drop the plus and minus 12 V dc required for amplifier operation down to the desired transducer excitation. The circuit is designed to drop each side of the supply by an equal amount with respect to the amplifier common line. This requirement is necessary to provide as low a common mode voltage as possible to the amplifier input.

The output voltage of the excitation regulator is adjustable by means of the 20,000 ohm potentiometer R56 or fixed in magnitude with programming resistor R57. When the voltage is adjustable, a jumper is connected across the terminals for R57 and Jumper F is open. When the voltage is programmed, Jumper F is wired in place.

As Excitation Zero pushbutton S2 is depressed the plus and minus excitation potentials are forced toward the common potential without disturbing the amplifier circuitry or shifting the input common mode dc level.

Unless otherwise specified, the output voltage of the Excitation Regulator is adjustable. To calculate the value of R57 to program a fixed voltage, see Section 4.3.

3.3 Sensing Do Not Unhook Leads At A+B

Terminal pairs A and B are provided for internally connecting the excitation regulator sensing leads when external sensing is not desired. The links A and B must be removed when external sense wires are used.

If a piezoresistive transducer is operated with this mode card, and the excitation wire resistance (2 wires) is greater than 10 ohms, external sensing wires are recommended.

CAUTION: The sensing leads must be connected either at the transducer or on the card for the post regulator to operate.

With the "monitor" switch, S2 on the 4470 Module, in the "excit" position, the sense leads are connected to the monitor output terminals. When jumpers A and B are installed on the mode card, the voltage on the monitor terminals is the output of the post regulator. If the sense wires are connected to the transducer, the monitor voltage is the voltage at the load.

3.4 Bridge Completion (Resistors R15, R16, R17)

If the mode card is used with a transducer having less than four active arms, the remaining arms of the bridge must be completed with fixed stable resistors. Because no terminals are provided for a bridge completion resistor between plus excitation and "A" signal input, one of the active arms must be connected between these two points.

3.5 Balance Limiting

The balance control, R28 on the 4470 module, is used to obtain electrical zero of the transducer output. An electrical offset may also be obtained with this control if desired. The range of balance voltage is set by 40.2 k ohm balance limiting resistor R58. For an equal arm bridge the range of adjustment is:

$$E_o = \pm \frac{E_x R_g}{4 R_s + 2 R_g} \quad \text{volts}$$

where: R_g = bridge arm resistance, ohms
E_x = excitation voltage, volts
R_s = balance limiting resistor (R58), ohms

If desired, the balance limiting resistor can be replaced with a large value of resistance to increase the resolution of zero adjustment and to reduce the slight loss of sensitivity due to the shunting of active arms. Rewriting the above equation:

$$R_s \leqq \frac{R_g}{4} \left(\frac{E_x}{E_o} - 2 \right) \text{ ohms}$$

3.5 Balance Limiting (Continued)

With the monitor switch, S2 on the front panel of the 4470 Module, in the "bal" position, the amplifier output is connected to the monitor output terminals. With no physical excitation at the transducer, the zero offset or unbalance voltage may be read at the monitor terminals.

3.6 Amplifier

The amplifier is comprised of three stages. The first stage is a high input impedance differential input pair whose differential gain is determined by the ratio of the feedback resistors R5 through R12. (Capacitor C_1 is used for flattening the response above 5 kHz on the two highest gain ranges.)

Because the input is a transistor pair and requires a D.C. bias current, the input source should provide a D.C. return path to common, or the excitation supply. While providing differential gain, the first stage also provides a voltage follower action to common mode signals, which are passed on to the next stage at unity gain.

The second stage converts the differential signal to a single ended output and provides additional amplification and common mode rejection. The gain of this stage is determined by the input and feedback resistor ratios and by R13, 19 and 20. R14 is used for gain calibration and R13 is used for nulling the common mode output. Gain selection is accomplished in this stage by changing the value of the feedback resistor. However, to preserve the common mode balance despite variations in feedback resistance, the unused feedback resistors are returned from the summing junction (at pin 2 of Z3) to "common," and the resistance from the summing junction to common mode "zero" potential remains a constant.

The output of the second stage has provisions for an optional low pass filter capacitor C2.

A 15 turn, 10 k potentiometer, R26 is used as an upranged vernier gain control. The gain steps are calibrated at the minimum gain setting (CCW) of the potentiometer.

The third stage Z4 is a non-inverting feedback amplifier. R30 and C3 are used to flatten the response above 5 kHz at maximum gain.

The last stage which includes Z5, Q1 and Q2, is an active filter and output circuit. Solder terminals are provided to add optional capacitors C4 and C5 which, together with C2, establish the high frequency rolloff.

A linear ±5 volt swing is available at load currents up to ±20 mA. Current is limited at approximately 50 mA, and the output voltage will clip at approximately ±7.5 volts.

The "A" signal output is in phase with "A" signal input at Z1. Guard Shield (chassis) MUST be connected to "common" (B signal) at the readout device.

3.7 Zero Calibration (Switch S2)

The zero calibration circuit provides an electrical zero reference level by removing the excitation voltage from the transducer. This is accomplished by depressing the "excit zero" pushbutton switch, S2 on the Mode Card.

The zero pushbutton on the front panel of the 4470 module and the zero relay K6 in the Module are not effective when using this mode card.

3.8 Calibration

Bifurcated solder terminals are provided for installation of up to four calibration resistors, R1 through R4. These resistors provide four-step bipolar single-shunt calibration.

The most accurate means for determining the values of the calibration resistors is by laboratory calibration. If this means is impractical or a high degree of accuracy is not required, the resistor value R_c for single shunt calibration may be calculated (see Section 4.5).

The mode card is normally shipped with jumper links across terminal pairs C, D, and E. With this configuration, external calibration leads are not required from the transducer to the internal calibration resistors. If external calibration wires are connected, remove jumpers C, D, and E.

3.8.1 Local Operation - The eight-position rotary switch, Calibrate Select, S1 on the front panel of the 4470 Module, selects one of the calibration resistors. When the switch is in position 1, resistor R1 is placed across one arm of the bridge, through the momentary push button switch, S4 labeled "calib." The resistor is connected to the bridge only when the calibrate switch is depressed. Similarly, switch position 2 connects resistor R2 across the same arm of the bridge, etc.

When the selector switch is in position 5, resistor R1 is placed across a different arm of the bridge, resulting in a calibration of the opposite polarity. Similarly, switch position 6 connects resistor R2 across the same arm of the bridge, etc.

3.8.2 Remote Operation (Relays K1 through K5) - Optional 24 Vdc relays, mounted in the 4470 Module, permit remote operation of the calibrate circuit. Relays K1 through K4 duplicate the operation of the first four positions of the calibrate selector switch and the "calib" push-button switch. When relay K1 is energized, R1 is placed across one arm of the bridge. When K2 is energized, R2 is connected, etc.

To obtain remote reverse polarity calibration, the polarity relay K5 must be energized simultaneously with the selected calibrate relay. When any relay is omitted, the normally closed contact terminals of the relay are jumpered (pin 5 to 6, and 8 to 9) and its corresponding diode replaced by a 3300 ohm, 1/4 watt resistor.

4.0 OPERATING INSTRUCTIONS

4.1 Transducer Connections

Refer to the functional wiring diagrams on Pages 18 to 21 for information on various transducer wiring configurations and details of circuit board preparations for each type. These diagrams show only a few of the many possible connections which can be made with this mode card.

Because no terminals are provided for a bridge completion resistor between plus excitation and "A," one of the active elements must be connected between these points (external terminals CC and MM).

Piezoresistive transducers with four active-arms are not recommended for use with this mode card since they cannot be shunt calibrated. Piezoresistive transducers with two active-arms and two internal bridge completion resistors can be used providing that the output between the active arms is connected to "A Input" and the output between the fixed resistors is connected to the "B Input." With this arrangement the mode card is capable of providing shunt calibration for the transducer.

The output of three-wire half-bridge piezoresistive transducers must be connected to "A Input." To permit the mode card to provide shunt calibration, link D must be connected to "B Signal Input," see wiring diagram on page 21. Unsolder the right side of link D and resolder to the right side of R58 (junction of R15 and R16). With some half-bridge transducers the first four calibration positions of the Calibration Selector switch will produce a calibration output with reserve polarity.

Before using a piezoresistive transducer, see Section 4.7, Step 6d.

4.2 Sensing (Links A and B)

Sensing links A and B are installed at the factory and provide for controlling the transducer excitation voltage at the mode card. If external sensing wires are used to regulate the voltage at the transducer, remove links A and B.

CAUTION: The sensing leads must be connected either at the load or on the card for the excitation regulator to operate.

4.3 Transducer Excitation Voltage

The Mode Card is wired at the factory for adjustable excitation voltage. For a fixed excitation voltage (from 100 mV to 15 V dc) install Jumper F and programming resistor R57, the value of which can be calculated from:

$$R57 = \frac{6E}{20-E} \text{ k ohms} \qquad \text{where: } E = \text{transducer excitation, volts.}$$

The resistor should be a high quality metal film type, having a temperature coefficient of approximately 50 ppm/°C (see Section 2.3).

Note: Total excitation current must not exceed 50 mA or 400 mW bridge dissipation.

4.4 Bridge Completion (Resistors R15, R16, R17)

If the transducer includes four arms connected in a bridge circuit, no additional components are required. If the transducer has less than four arms, install bridge completion resistors R15, R16 and/or R17 as required on the solder terminals. These resistors should be high quality, wire wound, such as Type RB55 per MIL-R-93.

4.5 Calibration Resistors (Resistors R1 through R4)

Determine the value of the single shunt calibration resistors by a laboratory test, or calculate from the formula:

$$R_c = \frac{R_g}{4}\left(\frac{E_x}{E_o} - 2\right) \text{ ohms}$$

where: E_o = change in transducer output desired, volts
E_x = excitation voltage, volts
R_g = bridge arm resistance

When using piezoresistive transducers connected as shown in the wiring diagrams on Page 21, the bridge completion resistors are shunted by R_s the balance limiting resistor R58. For most accurate calculation of calibration resistors, replace R_g in the above formula with R_e, the effective bridge arm resistance, where:

$$R_e = \frac{R_g R_s}{R_g + R_s} \text{ ohms}$$

The calibration resistors should be high quality type such as RN-55 metal film or equal. Install the resistors on the pairs of solder terminals provided (see Outline Drawing D-4476.2A-1C). IMPORTANT: See Caution Note in Section 2.3.

4.6 Low Pass Filter

The frequency response of this mode card is within ±5% from dc to 10,000 Hz and is less than 3 dB down at 20,000 Hz. Provision is made to add capacitors for optional high frequency rolloff. This optional low pass active filter can be either single, second, or third order, with a terminal slope approaching -6 dB, -12 dB, or -18 dB per octave, respectively. The equations for calculating filter capacitors C2, C4 and C5 are given below together with the necessary constants, K_x, which depend on the type of filter desired.

f_c is the frequency for -3 dB response in the Butterworth type filter, and the corner frequency in a Tchebycheff type filter.

4.6 Low Pass Filter (Continued)

Order	Terminal Slope	Type	K_1	K_2	K_3
1	- 6 dB	---	1.0	*	*
2	-12 dB	Butterworth	**	1.0	1.414
3	-18 dB	Butterworth	1.0	1.0	1.0
3	-18 dB	Tchebycheff	1.303	0.747	0.573

* C4 and C5 capacitors not used. ** C2 not used.

$$C2 = \frac{59.9\ K_1}{f_c}\ \mu F \qquad C4 = \frac{47.7\ K_2}{K_3\ f_c}\ \mu F \qquad C5 = \frac{5.31\ K_3}{f_c}\ \mu F$$

Install axial lead stable capacitors in the locations shown on the outline drawing. Capacitors should not exceed the following dimensions:

C2: 1/2" dia x 1-3/8 long (12.5 x 35 mm)
C4 and C5: 5/16" dia x 7/8" long (8 x 22 mm)

4.7 Measuring Acceleration, Pressure, Force, etc.

1. Connect the transducer and readout equipment, and prepare the mode card in accordance with Sections 4.1 through 4.6. Turn the gain step switch to the x1 position. Turn Excitation Adjust fully counterclockwise.
2. Plug the mode card into the 4470 Module, apply power, and allow the instrument to warm up for at least half an hour.
3. With the "monitor" switch in the "excit" position, read the excitation voltage at the monitor terminals and turn Excitation Adjust clockwise until the desired voltage is obtained.
4. Depress the "excitation zero" push-button switch on the mode card and at the same time move the monitor switch to "balance." Adjust the "amplifier zero" potentiometer for an amplifier output null at the monitor terminals.
5. With rated excitation on the transducer push the monitor switch to "balance" and adjust the "balance" potentiometer on the Module for an output null at the monitor terminals.
6. Adjustment of Amplifier Gain
   a) To operate the amplifier at an accurate, known gain of 1, 3, 10, 30, 100, or 300, turn the gain vernier to its CCW stop and set the gain step switch to the desired gain.

4.7 Measuring Acceleration, Pressure, Force, etc. (Continued)

6. Adjustment of Amplifier Gain (Continued)

b) If the full scale output voltage of the amplifier is to be set at a whole number multiple of the full scale measurand (acceleration, force, pressure), apply the full scale measurand to the transducer and adjust the gain step switch and gain vernier for the selected output voltage (5.0 volts or less).

c) If one of the calibration resistors has been calculated to provide full scale output, set the "calibration selector" switch to that resistor, depress the "calibration" push-button on the 4470 Module and adjust the gain step switch and gain vernier for the desired full scale output voltage (5.0 volts or less).

d) CAUTION: Gains greater than 80 are not recommended when using piezoresistive transducers. Amplification of zero shifts due to thermal variations of the transducer may result in errors in the output data.

7. Important: Repeat steps 4 and 5, above, to reset the null output with the amplifier operating at the selected gain.

8. The instrument is now ready to condition the signal from the transducer.

9. To obtain calibrated reference dc output voltages, depress the "calib" push-button on the 4470 Module and rotate the "calibration selector" switch through positions 1 through 8. These operations are duplicated remotely by energizing the optional relays in the 4470.

5.0 INITIAL SET UP AND CHECKOUT

5.1 Unpacking and Inspection

The mode card has been thoroughly tested and inspected at the factory and should be ready for operation when received (except for calibration and bridge completion resistors). However, the customer should make an inspection to make certain that no damage has occurred during shipment. Obvious damage should be reported immediately to the carrier.

5.2 Checkout Procedure

The following sections describe the recommended procedures for checking the operation of the Model 4476.2A Mode Card in a Model 4470 Module. These may be used during incoming inspection or for periodic maintenance.

5.2.1 Test Equipment - The following test equipment is required:

Oscillator
Differential dc Voltmeter
AC Voltmeter
Variable Transformer - Gertsch #216 Ratiotran or equal
or
Voltage Divider - General Radio Type 1455-A or equal
Isolation Transformer - Gertsch #200 or equal (1:1 ratio)
Switch - SPDT
Load Resistor - as required for Excitation Test
Convenience Cable - Endevco Model 15769 (optional)

5.2.2 Initial Connections and Control Settings:

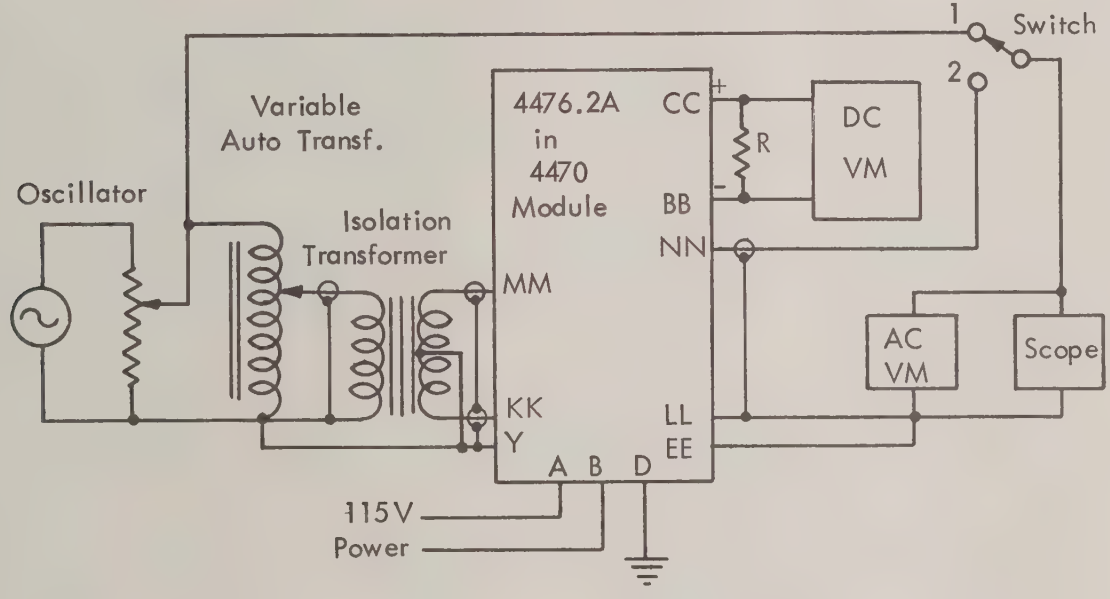


Figure 1

Connect the equipment as shown in Figure 1. All leads must be shielded. Set the front panel controls as follows:

Gain Switch	x1
Gain Vernier	maximum CCW
Excitation Adjust	maximum CCW
Variable Transformer	0.000

Insert the mode card, turn on power, adjust and maintain power voltage at 115 Vac (230 Vac for Model 4470V, 100 Vac for Model 4470W). Allow at least 20 minutes warmup before making measurements.

5.3 Excitation Regulator Voltage

If bridge completion resistors have been installed on the mode card, disconnect them by unsoldering one end of each resistor and lift that end away from the terminals. Reconnect the resistors after this test.
REMOVE LINKS A+B DURING THIS STEP ON UUT

Connect a differential dc voltmeter and a 1 watt resistor to the excitation output terminals CC and BB. The value of the resistor should be greater than:

$$R = \frac{E^2}{0.400} \text{ ohms, for outputs of 8 to 15 volts}$$

$$R = \frac{E}{0.050} \text{ ohms, for outputs less than 8 volts}$$

where: E = excitation voltage, volts

Turn the excitation adjust potentiometer clockwise until the dc voltage is equal to excitation E selected above. Disconnect the resistor and note the reading on the dc voltmeter. The excitation voltage should not change more than 0.01% of E.

If the programming resistor R57 has been installed, the output voltage should be as selected (see Section 4.3), ± twice the tolerance of the programming resistor and ±2 mV.

5.4 Amplifier Zero

Connect the dc voltmeter to the output terminals NN and LL. Turn the variable transformer to its CCW position at 0.000 (zero output). Set the gain vernier potentiometer to its maximum CCW position (minimum gain).

Depress the "excitation zero" button on the mode card and check the range of the "amp zero" potentiometer at each of the gain step positions. It should be possible to obtain a zero dc output on all gain ranges.

Turn the gain switch to x300, depress the "excitation zero" button, and adjust the "amp zero" potentiometer for an output of zero ±5 mV. Return the gain switch to x1 and disconnect the voltmeter.

Note: The resistance across the input terminals should be constant through all tests. A change in resistance will result in a dc offset at the output which may cause clipping of the signal.

5.5 Residual Noise

With the signal conditioner connected as shown in Figure 1, turn the oscillator down and the variable transformer to the CCW position at 0.000 (zero output). Set the gain switch to x1 and the gain vernier to its maximum CCW (calibrated) position. The noise on the amplifier output as observed on a true rms voltmeter should be less than 0.5 mV rms.

Turn the gain switch to x300. The output noise, measured with a true rms voltmeter should be less than 3 mV rms.

5.6 Gain Accuracy

With the mode card connected as shown in Figure 1, set the controls as follows:

Gain Switch	x1
Gain Vernier	maximum CCW
Variable Transformer	1.000
Oscillator	100 Hz

Set the input-output switch to Position 1 and increase the output of the oscillator for 1.00 Volt rms at the input to the variable transformer. With the switch in Position 2, read the output of the amplifier. It should be 1.00 V rms ±1.5%.

Change the setting on the variable transformer to 0.333, turn the gain switch to X3, and check for 1.00 V rms at input-output switch position 1. The output voltage at switch position 2 should be 1.00 V rms ±1.5%.

Similarly, repeat the above procedure for each of the gain step positions. During each measurement check for 1.00 V rms at the input to the variable transformer.

Test No.	Variable Transformer	Gain Switch
A	1.000	x1
B	.333	x3
C	.1000	x10
D	.0333	x30
E	.0100	x100
F	.00333	x300

At each step the output wave shape should be undistorted, and the output voltage should be 1.00 V rms ±1.5%.

5.7 Gain Vernier Range

Set the gain switch to x1, turn the gain vernier to its CCW stop and set the variable transformer to 0.2857. Adjust the oscillator for 100 Hz and 1.00 V rms to the input of the variable transformer. Turn the gain vernier to its clockwise stop. The output of the amplifier should be greater than 1.00 V rms.

6.0 MAINTENANCE AND TROUBLESHOOTING

A Model 13423 Test Adapter is available to operate the mode card outside the 4470 Module. When the card is operated in this position all terminals and components are accessible for test or adjustment. Terminals on the adapter provide a means for connecting a voltmeter or oscilloscope to the mode card contacts.

6.1 Maintenance

Very little maintenance is normally required to keep the mode card in good operating condition. It is recommended that periodic cleaning of the gold contacts on the end of the card will assure trouble-free operation when the equipment is needed.

Wipe the contacts with a lint-free, non-abrasive material (Kimwipe) wetted with alcohol, and slightly burnish the gold surface to remove dirt, oil, or finger marks which may cause corrosion and high resistance. When a card is to be used after long storage, plug the card in and out of the 4470 several times to insure clean and low resistance contacts.

6.2 Troubleshooting and Adjustments

If a malfunction occurs, the area of trouble usually can be found by measuring voltages at various points on the circuit board and tracing a signal through the circuit. Test point TP4 is common or ground, and is suggested as a reference terminal. After replacement of a component the mode card should be tested in accordance with Section 5 of this manual.

If the mode card does not meet specification tolerances, adjustments can be made in accordance with the procedures in the following sections.

Note: Some adjustment potentiometers are sealed with Glyptal. After completing the adjustment, reseal with Glyptal or other equivalent material.

6.3 Gain Adjustment

6.3.1 Perform the Gain Accuracy Test in accordance with the procedure described in Section 5.6. At each gain step record the percent deviation in output voltage from 1.00 volts rms, noting the direction of the error whether plus or minus. The The spread, defined as the sum of the maximum positive deviation and maximum negative deviation, should not be greater than 3%.

If any deviation exceeds 1.5%, adjust the gain calibration potentiometer R14 to divide the spread equally around zero deviation. If the spread is greater than 3%, one of the gain determining resistors has changed and should be replaced.

CAUTION: Gain adjust R14 and common mode null adjust R13 interact. If one of these potentiometers is readjusted it will be necessary to readjust the other. See Section 6.4.

6.3.2 Location of a faulty component is simplified by measuring the gains of the first stage (Z1 and Z2) and the third stage (Z4). The gain of Z3 will vary from amplifier to amplifier and cannot be predicted.

To measure the gain of the first stage, turn gain vernier to its CCW stop, apply the specified voltage to the input terminals MM and KK (Figure 1). Measure the differential output from pin 6 of Z1 to pin 6 of Z2 (test point TP 1 to test point TP 2).

To measure the gain of the third stage, turn the gain vernier fully clockwise, apply the specified signal to the C2 terminals and measure the voltage at the output of the amplifier.

	First Stage (Z1, Z2)		Third Stage (Z4)	
Gain Switch Setting	Maximum Input Volts rms	Gain ±1%	Maximum Input Volts rms	Gain ±1.5%
x1	1.00	1.0	.60	5.0
x3	.333	3.0	.60	5.0
x10	.100	2.0	.60	5.0
x30	.0333	6.0	.60	5.0
x100	.0100	10.0	.60	5.0
x300	.00333	12.5	.25	12.0

6.4 Common Mode Adjustment

Because the gain adjust R14 and common mode null adjust R13 interact, any adjustment of one requires that the other be also adjusted.

Connect the isolation transformer as follows:

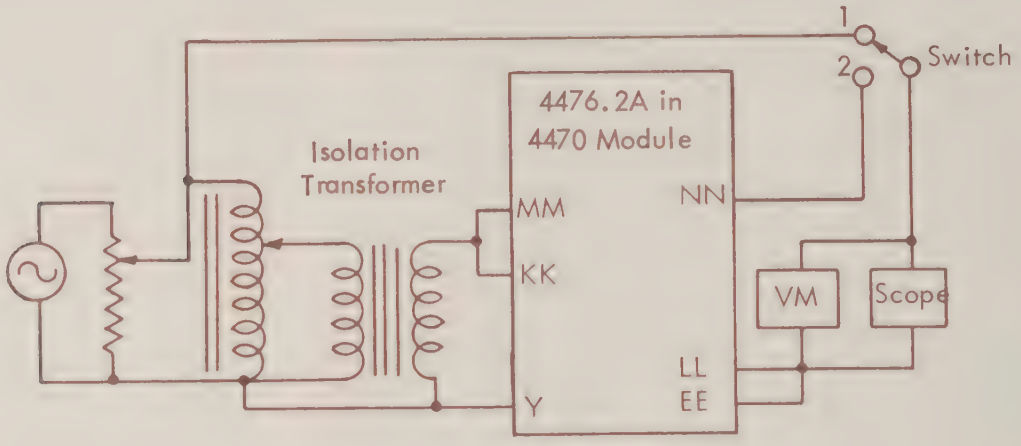


Figure 2

Set the gain switch to x1, turn the gain vernier fully CCW, and the variable transformer to 1.000. Apply a 100 Hz, 1.00 V rms signal to the variable transformer. The voltage at the output of the amplifier should be less than 0.5mV rms or the residual output noise level. If the output is greater than 0.5 mV rms adjust R13 for minimum output signal.

If it is necessary to adjust R13, connect the isolation transformer as shown in Figure 1, and measure the amplifier gain without changing the front panel controls. Readjust the gain calibration potentiometer R14, if necessary (see Section 6.3). Check the common mode adjustment again in accordance with the previous paragraph.

6.5 Output DC Offset Adjustment

Short together the input terminals MM and KK, and connect them to terminal Y. Connect a dc voltmeter to the output terminals of the amplifier. Check the amplifier zero offset in accordance with the procedure in Section 5.4.

6.5 Output DC Offset Adjustment (Continued)

If zero output cannot be acheived on all gain step positions, it may be necessary to adjust the dc offset controls as described below. This adjustment should be made if the "amplifier zero" potentiometer will not zero the output of the amplifier with the "excit zero" button, on the mode card, depressed.

1. Set the gain switch to x300. Connect a short clip lead (jumper) from Pin 6 of Z4 (also right side of R33) to Common (right side of C4). Adjust Offset #1 (R38) for 0 ±0.5 mV dc at the amplifier output. Remove jumper.

2. Connect a short clip lead (jumper) across capacitor C2 terminals. Adjust the "gain vernier" potentiometer for a maximum negative output. Then adjust R31 (Offset #2) for zero ±0.5 mV dc at the amplifier output. Remove the jumper.

3. Plug the mode card inside an operating 4470 Module and allow at least 10 minutes for warmup. After warmup, and with the card inside the 4470, set the "gain vernier" potentiometer to maximum gain (CW). Switch the gain switch alternately between x10 and x30 ranges and adjust R8, "amp zero" potentiometer until there is no dc shift when switching.

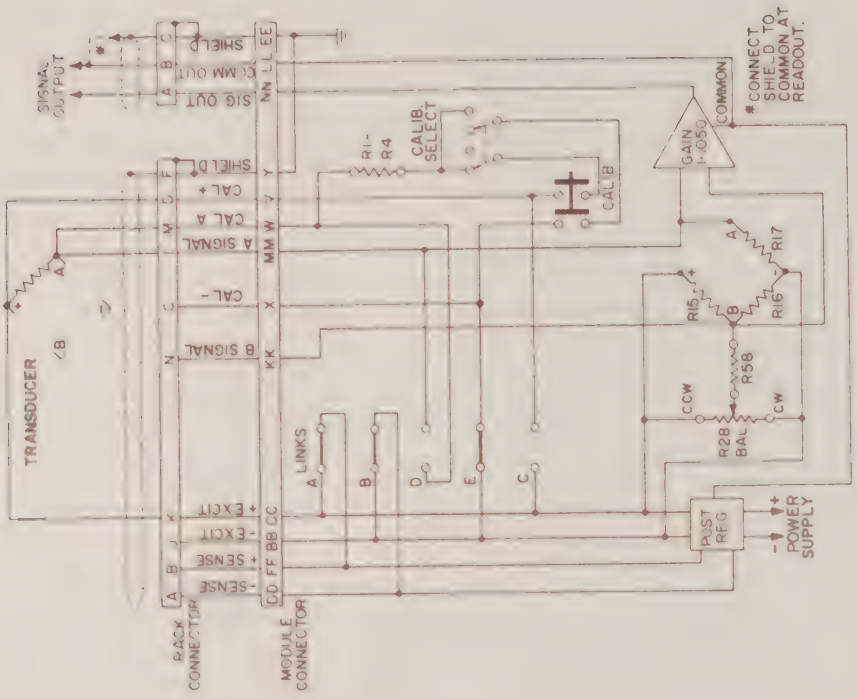
4. Turn the gain switch to x10. While the mode card is still warm, operate it outside the 4470 by means of the Test Adapter and adjust R24 (Offset #3) for zero ±0.5 mV dc at the amplifier output.

5. Rotate the gain switch through all ranges. If the dc change at the output is greater than 5 millivolts, repeat Steps 1, 2, 3 and 4.

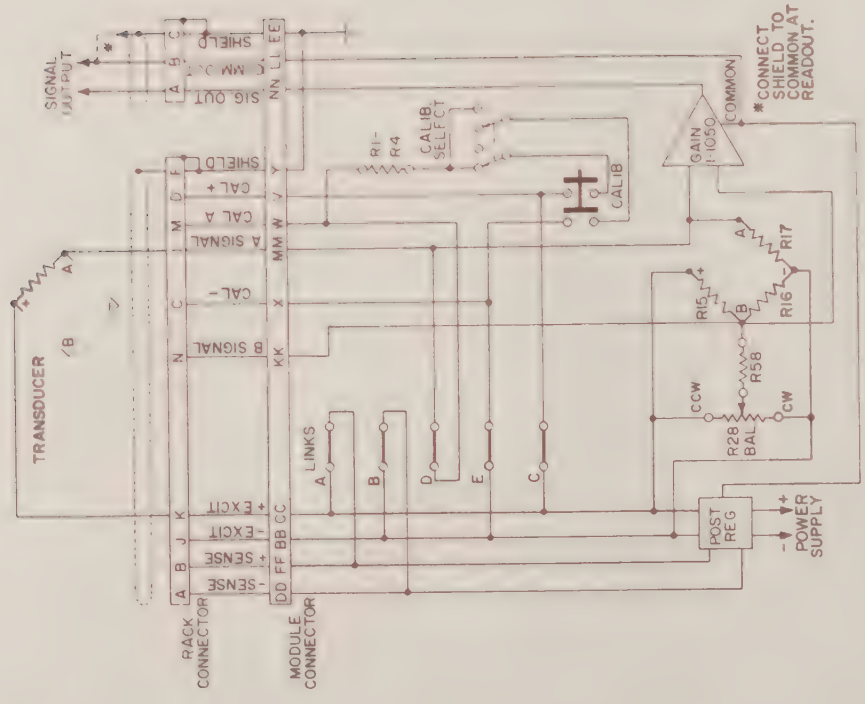
6.6 Factory Repairs

If serious trouble occurs, and the mode card cannot be calibrated, the instrument should be returned to the factory, transportation charges prepaid. See the Warranty enclosed with this manual. Whenever possible, the equipment should be accompanied by a statement describing the malfunction in detail. All shipments and correspondence should be addressed to:

Service Department
Endevco
Rancho Viejo Road
San Juan Capistrano, CA 92675



4 Wire System

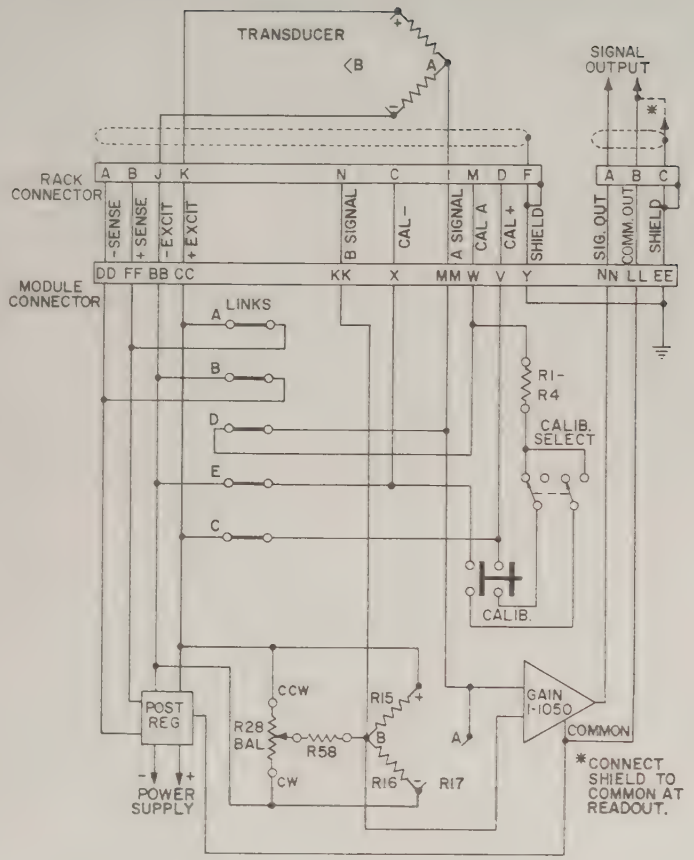


2 Wire System

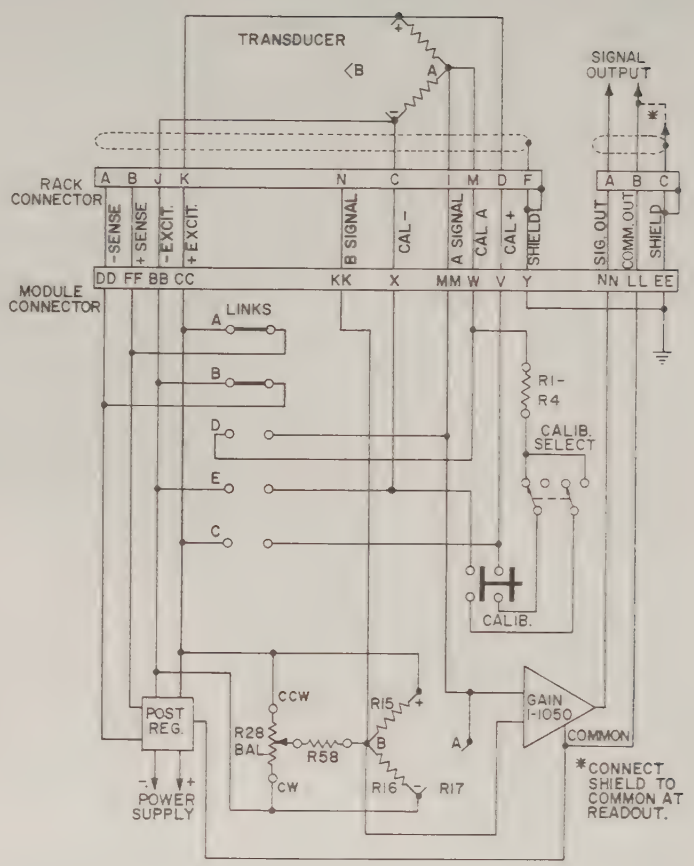
WIRING DIAGRAM MODEL 4476.2A/4470

Single Active Arm, Single Shunt Calibration

Note: When reverse polarity of calibration is used, the calibration resistor shunts the passive arm.



3 Wire System

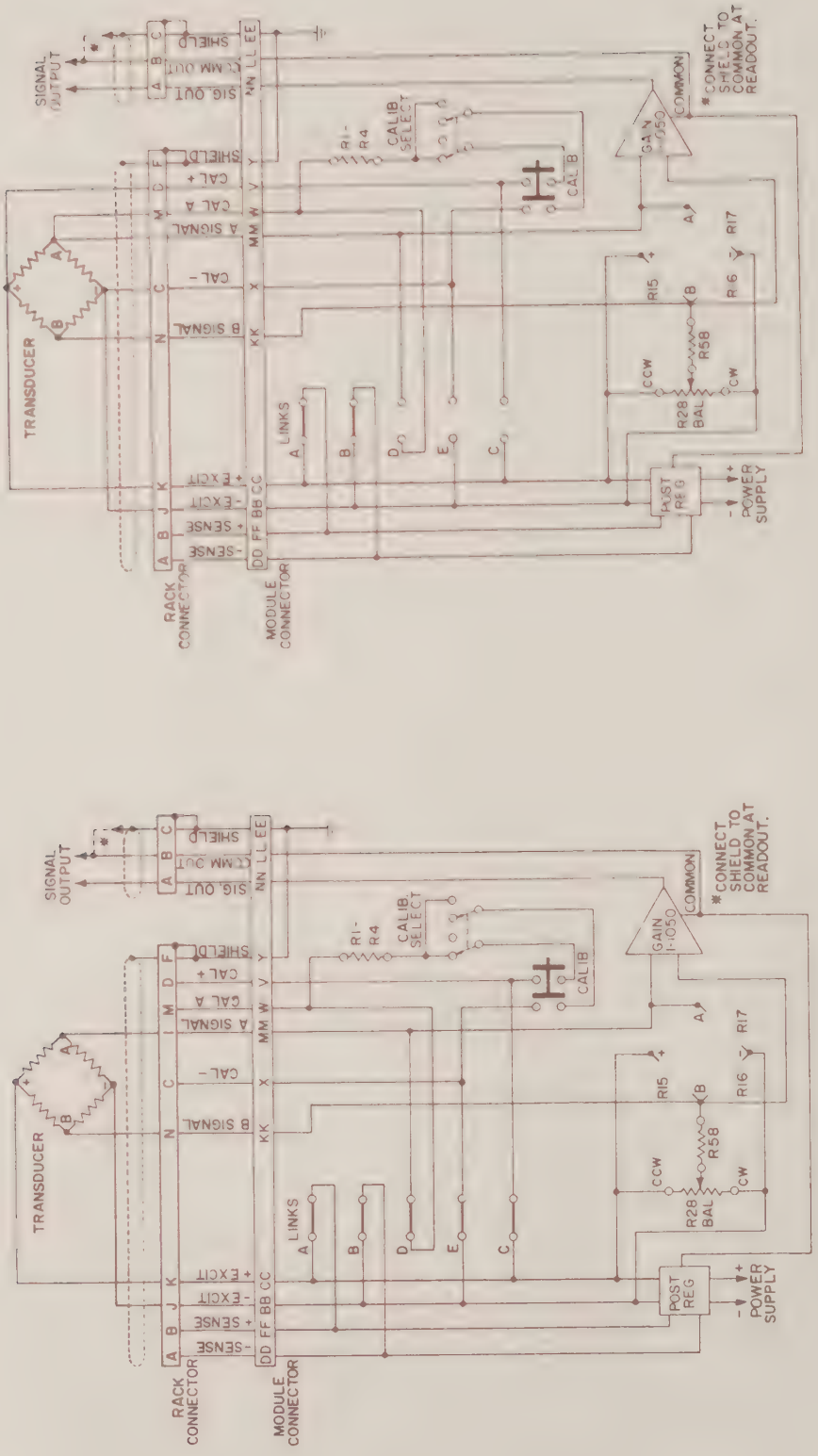


6 Wire System

WIRING DIAGRAM MODEL 4476.2A/4470

2 Active Arm, Single Shunt Calibration

For Piezoresistive Accelerometers, see Page 21.

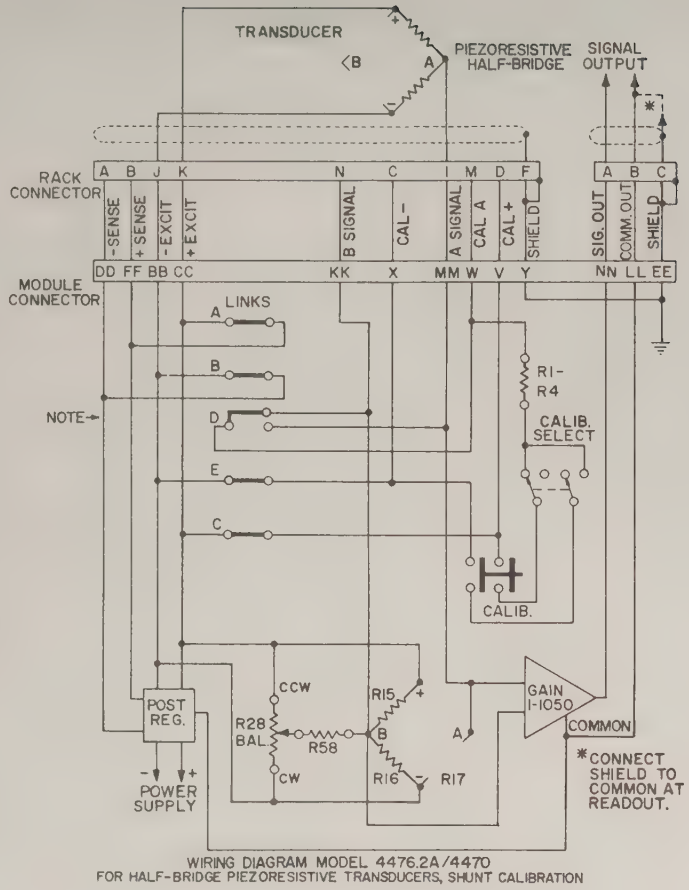


4 Wire System

7 Wire System

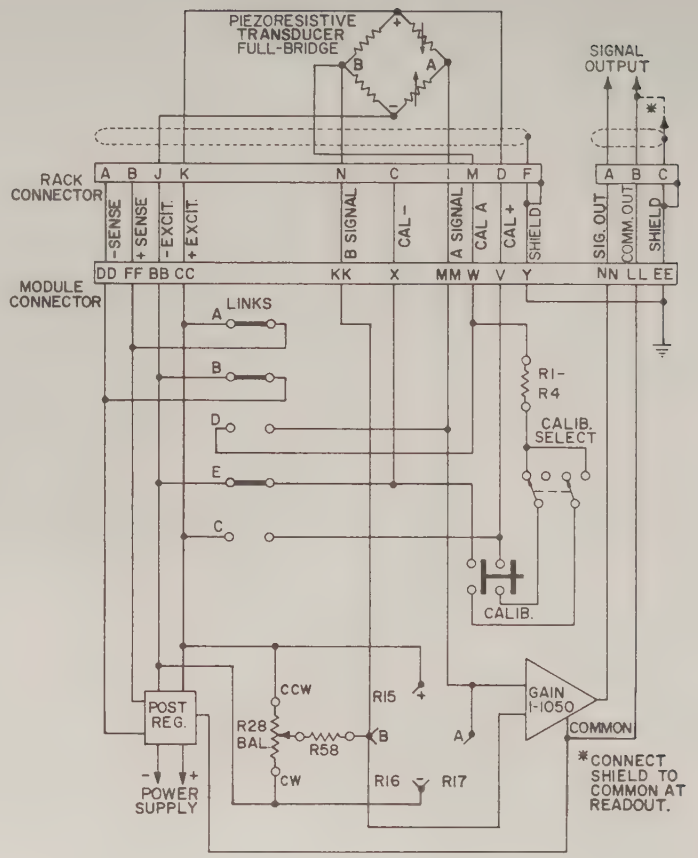
WIRING DIAGRAM MODEL 4476.2A/4470

4 Active Arms, Single Shunt Calibration
For Piezoresistive Transducers, see Page 21.



WIRING DIAGRAM MODEL 4476.2A/4470
FOR HALF-BRIDGE PIEZORESISTIVE TRANSDUCERS, SHUNT CALIBRATION

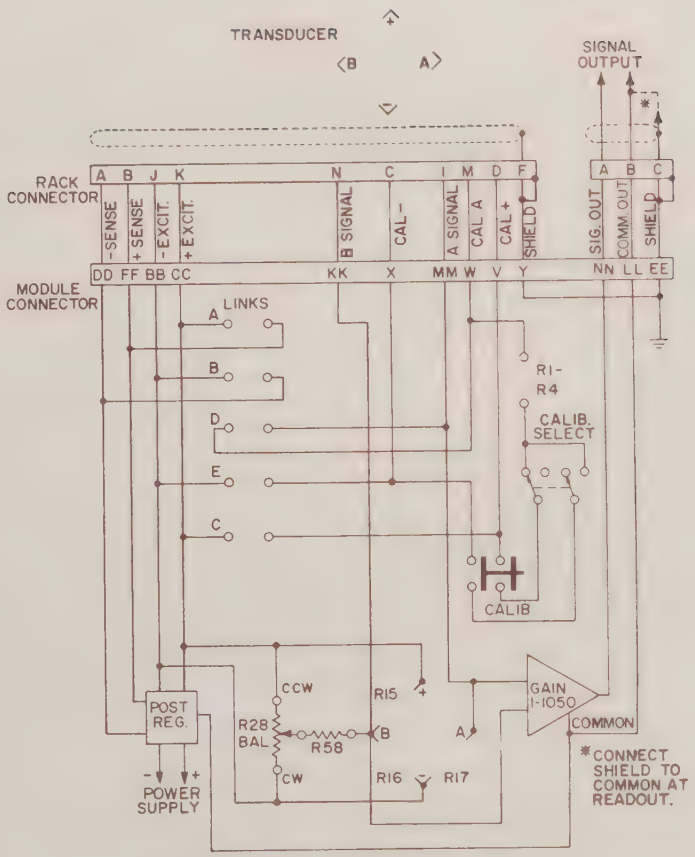
3 Wire System
Half-Bridge



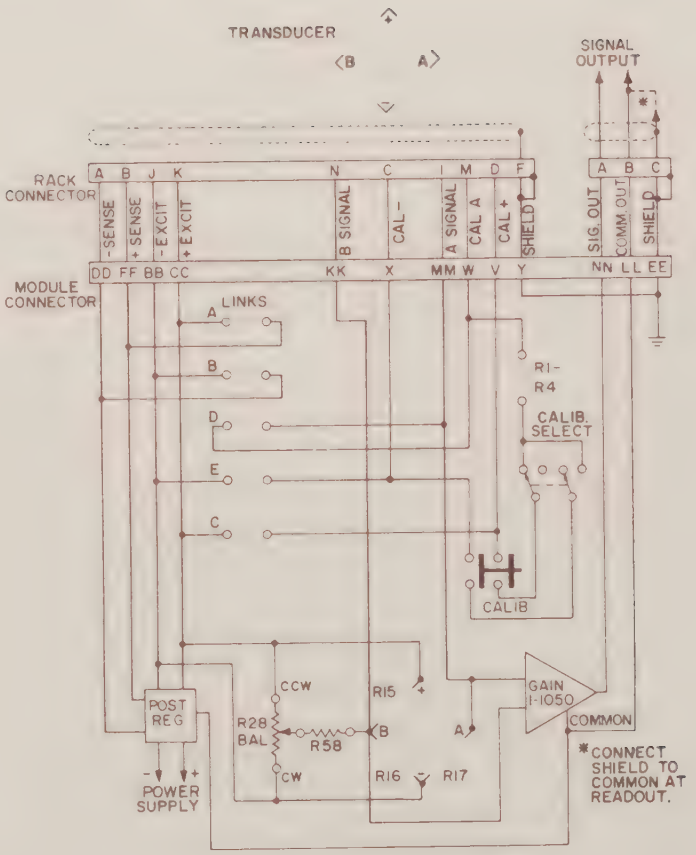
6 Wire System
Full-Bridge

WIRING DIAGRAM MODEL 4476.2A/4470

Piezoresistive Transducers
Single Shunt Calibration



Work Sheet



Work Sheet

WIRING DIAGRAM MODEL 4476.2A/4470

A4476.2A-508C B

Originated By: PT 11-7-72	PERFORMANCE SPECIFICATION MODEL 4476.2A AMPLIFIED BRIDGE CONDITIONER	Dwg. No: A4476.2A-508C
Checked By: PT		Page 1 / 5
Approved By: DH RHR		Rev. No: B EO
		Rev. Date 4/25/74 13315

1.0 DESCRIPTION

The ENDEVCO® Model 4476.2A Plug-In Card is an Amplified Bridge Conditioner for use with the ENDEVCO® Model 4470 Module and provides the signal conditioning functions, including amplification, for resistive transducers and strain gages.

This card provides six calibrated steps of amplification and a front panel adjustable or internally programmable, regulated bridge excitation voltage with provisions for external sensing, ZERO (excitation removal), internal-external shunt calibration, bridge completion and balancing, and optional low pass filtering.

2.0 ELECTRICAL CHARACTERISTICS

2.1 Amplifier

The amplifier has a differential input, a single-ended output and a total gain range from 1.0 to 1,050. The gain is selected by means of a 6-position gain multiplier switch in steps of 1, 3, 10 30, 100, 300 and a screwdriver adjustable 1.0 to 3.5 up-ranged 15-turn vernier potentiometer.

A screwdriver adjustable "Amplifier Zero" control for nulling the amplifier DC offset is also provided on the front panel.

2.1.1 Input Characteristics

2.1.1.1 Input: Differential

2.1.1. Input Bias Current: Less than 500 nA

2.1.1.3 Input Impedance: 100 Megohms in parallel with 50 pF

2.1.1.4 Input Source Resistance: 4 k maximum

2.1.1.5 Maximum Input Voltage: ±5 volts peak at unity gain.

2.1.1.6 Maximum Common Mode Voltage: ±(5.0 volts-peak input signal).

2.1.2 Transfer Characteristics

2.1.2.1 Amplification: The total amplification is adjustable from 1.0 to 1,050 by means of a six position calibrated gain switch and a screwdriver adjustable vernier control which overlaps the gain ranges.

2.1.2.2 Gain Steps: 1, 3, 10, 30, 100, 300 with a 1.0 to 3.5 15-turn screwdriver vernier adjustment.

CONTINUED PRODUCT IMPROVEMENT NECESSITATES THAT ENDEVCO RESERVE THE RIGHT TO MODIFY THESE SPECIFICATIONS WITHOUT NOTICE TO HOLDERS OF PREVIOUS ISSUES.

Originated By:	PERFORMANCE SPECIFICATION	Dwg. No. A4476.2A-508C
Checked By:	MODEL 4476. AMPLIFIED BRIDGE CONDITIONER	Page 2 / 5
Approved By:		Rev. No.:
		Rev. Date:

2.1.2.3 Gain Step Accuracy: ±1.5%, calibrated at maximum CCW (minimum gain) setting of the vernier control.

2.1.2.4 Gain Time Stability: 0.01%/24 hours.

2.1.2.5 Gain Temperature Stability: 0.003%/°F.

2.1.2.6 Frequency Response: ±5% dc to 10 kHz. Less than 3 db down at 20 kHz.

2.1.2.7 Phase Shift: Less than 30° to 10 kHz.

2.1.2.8 Low Pass Filter: Terminals are provided for optional high frequency rolloff capacitors (C2, C4 and C5).

The optional low pass filter can be either single, second or third order, i.e., terminal slope approaching -6, -12, or -18 db/octave respectively. Equations for calculating the values of C2, C4 and C5 are given below together with the necessary constants depending upon the type of filter desired.

$$C2 = \frac{59.9K_1}{f_c} \quad \mu F$$

$$C4 = \frac{47.7K_2}{K_3 f_c} \quad \mu F$$

$$C5 = \frac{5.31K_3}{f_c} \quad \mu F$$

f_c is the cutoff frequency in Hz, i.e., the -3db frequency for a Butterworth type filter, and the ripple bandwidth (-0.25 db) for a Tchebycheff type filter.

Order	Type	K_1	K_2	K_3
1	-	1.0	*	*
2	Butterworth	**	1.0	1.41421
3	Butterworth	1.0	1.0	1.0
3	Tchebycheff	1.30340	0.747060	0.573162

2.1.2.9 DC Linearity: Less than ±2.5 mV from best fit straight line through zero over a ±5 volt output range.

Note: * C4 and C5 not used
** C1 not used

Originated By:	PERFORMANCE SPECIFICATION MODEL 4476.2A AMPLIFIED BRIDGE CONDITIONER	Dwg. No: A4476.2A-508C Page 31 5 Rev. No: Rev. Date
Checked By:		
Approved By:		

2.1.2.10 Common Mode Rejection: Less than the output noise level with ±5 volt common mode input at unity gain (80 db minimum, increasing with the gain setting) below 100 Hz.

2.1.2.11 Overload Recovery Time: 20 μsec

2.1.3 Output Characteristics

2.1.3.1 Output: Single ended

2.1.3.2 Maximum Output Voltage: ±5 volts peak (clipped at ±7.5 volts, nominal)

2.1.3.3 Maximum Output Current: ±20 mA (limited at ±50 mA, nominal)

2.1.3.4 Output Impedance: Less than 1 ohm

2.1.3.5 Noise and Ripple: Below 0.5 mV rms R.T.O. or 10.0 μV rms R.T.I. wideband.

2.1.3.6 Amplifier Zero: Adjustable over ±5 mV R.T.I.

2.1.3.7 Zero Time Stability: 0.01% F.S. plus 40 μV R.T.I. for 24 hours.

2.1.3.8 Zero Temperature Stability: 0.005% F.S./°F plus 10 μV/°F R.T.I.

2.1.3.9 Capacitive Load Effects: Stable to 10 uF

2.1.3.10 Short Circuit Protection: The amplifier is current limited and will not be damaged by a short circuit at the output.

2.2 Post Regulator

The purpose of the regulator is to supply a balanced source of excitation voltage to the bridge. Each side of the ±10 V dc from the 4470 is dropped by an amount determined by the excitation adjustment potentiometer (R56).

For fixed voltage programming install jumper F across adjustment potentiometer (R56). The value of R57 for the desired excitation voltage E is given by

$$R57 = \frac{6E}{(24-E)} \text{ Kilohms}$$

The excitation supply may be sensed externally by removing the appropriate jumpers (A and B) and providing the required external connections.

The excitation may be removed with the "EXCITATION ZERO" pushbutton (The 4470 "ZERO" pushbutton is inoperative.) Upon Depression of the pushbutton, the + and -sides of the bridge are forced towards a ±common potential without disturbing the amplifier circuitry or shifting the input common mode dc level.

2.2.1 Output Voltage: Front Panel adjustable from 12 mV to 15 V dc (factory set to 10.0 V ±1%)

2.2.2 Regulator Sensing: Internal or external. 500 nA (max) sensing current

2.2.3 Output Capability: Limited to 50 mA, or 400 mW bridge dissipation.

2.2.4 Line Regulation: Less than 0.015% change in output voltage for line voltage variation from 95 to 135 V ac.

2.2.5 Load Regulation: Less than 0.02% change in output voltage from no load to 50 mA load.

2.2.6 Noise and Ripple: 25 µV rms maximum dc to 20 kHz.

2.2.7 Temperature Stability: Less than 0.005%/°F or 10 µV/°F.

2.2.8 Time Stability: Less than 0.05% for 48 hours for constant line, load and temperature.

2.2.9 Excitation Zero: Reduces the excitation to less than ±12 mV.

2.2.10 Short Circuit Protection: The regulator will not be damaged by a short circuit at the output.

2.3 Bridge Completion and Balancing

Terminals are provided for installation of three bridge completion resistors (R15, R16, R17)

A 40.2k balance limiting resistor (R58) connects the slider of the 4470 balance potentiometer into the bridge circuit. The balance potentiometer is connected across the bridge excitation supply.

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Originated By:	PERFORMANCE SPECIFICATION	Dwg. No. A4476.2A-508C
Checked By:	MODEL 4476.2A	Page 5 / 5
Approved By:	AMPLIFIED BRIDGE CONDITIONER	Rev. No.:
		Rev. Date:

2.4 Calibration Circuitry

Four steps of bipolar single shunt calibration are available (eight steps total). Terminals are provided for installation of four calibration resistors, R1, R2, R3 and R4. The calibration resistors may be connected internally, or externally by removing jumpers C, D and E and provideing the required external connections.

3.0 ENVIRONMENTAL CONDITIONS

3.1 Temperature

+15°F to +150°F.

ENDEVCO PRODUCT DATA

UNIVERSAL SIGNAL CONDITIONING SYSTEM SERIES 4470

MODEL 4470 MASTER MODULE

Endevco's Model 4470 Series Universal Signal Conditioning System employs a concept of versatility to meet today's diverse requirements.

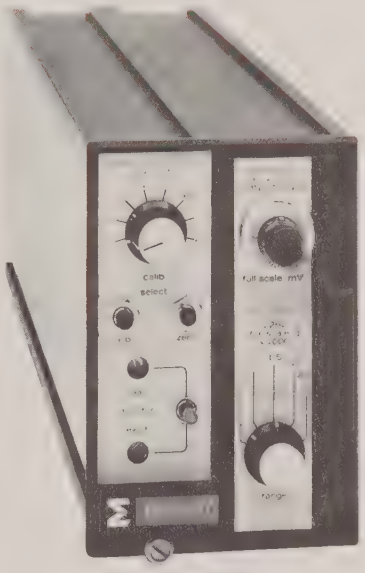
The master module of this system consists of three basic sections; a highly regulated instrument power supply, calibration circuitry (including the optional remote calibration relays if used), and passive conditioning circuitry and components.

Components of the system are all routed through the Mode Card for interconnection in the optimum conditioning circuit for the transducer being used. Insert a new Mode Card and you have a new signal conditioner. With the variety of Mode Cards available and the blank Designer's Card which allows you to design your own, you always have an up-to-date system.

Components common to all or most operating modes are located in the master module where all circuits can call upon them. Components used in only one or two modes are located on the individual Mode Cards where they are needed. All parts of the system are enclosed within a single shielded enclosure, the master module, into which the individual Mode Cards are inserted. This results in the best possible shielding and the best possible data.

The heart of any signal conditioner for DC-excited transducers is its power supply, and the 4470 has one of the best. This all-silicon, solid state supply is designed to provide optimum voltage regulation or current regulation of its output by Mode Card selection. The operating mode, be it constant voltage or constant current, resistance programmable or front panel adjustable, is set by the same card that determines conditioning and calibration. With this system there are no mixups because of a switch left in the wrong position.

Among the really outstanding features of this supply are: electronic current limiting with automatic recovery in the constant voltage mode (voltage limiting in the constant current mode), external sensing capability with low sensing current (312 μA), and a really fast load transient recovery time (less than 50 μsec from no load to full load or full load to no load).

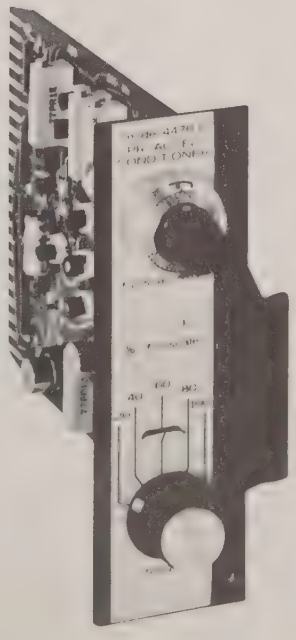


MODEL 4470 SERIES MODE CARDS

The Mode Card for a particular system (identified as 447X.X) contains the circuitry necessary to select and interconnect the components of the master module, as well as provision for mounting calibration and standardizing resistors.

Special components required for that system and not provided in the master module are located on the plug-in card along with active circuitry (amplifiers, oscillators, etc.) if required.

A variety of plug-in Mode Cards are available, including the Model 4475.1 Designer's Card which allows you to accommodate prototype or "one-shot" conditioning circuitry for special applications. Mode Cards are listed on the 4470 System Accessory List.



ELECTRICAL SPECIFICATIONS

Power Supply Specification

As a Voltage Regulated Supply
(with 4471.1A Mode Card)

Output Voltage	1 to 30 V dc
Output Voltage Resolution	5 mV nominal
Output Current	0 to 100 mA
Current Limit Point	140 mA nominal
Line Regulation	Within 0.01% of setting or 500 μV whichever is greater for line changes from 95 to 135 V rms
Line Transient Response	No overshoot or ringing outside of the regulation limits for line transients from 95 to 135 V rms
Load Regulation	Within 0.01% of setting or 500 μV whichever is greater for load changes from no load to full load or full load to no load
Load Transient Response	Recovery to within 0.01% of setting in less than 50 μs for load changes from no load to full load or full load to no load
Noise and Ripple (normal mode)	100 μV pk-pk max., DC to 10 kHz
Output Impedance	.1Ω to 2 kHz .5Ω to 20 kHz
Temperature Stability	Less than 0.003% / °F of setting or 150 μV / °F whichever is greater
Time Stability	Within 0.03% of setting or 1.5 mV whichever is greater for 48 hours with line, load and temperature held constant
Sensing Current	312 μA
Resistance Programming	3.2 k ohms / volt ±0.1% plus ±2 mV

As a current regulated Supply
(with 4471.2A Mode Card

Output Current	0.5 to 5 mA low range 5 to 50 mA high range
Compliant Voltage Range	0 to 25 V dc
Voltage Limiting Point	35 V dc
Line Regulation	0.01% low range or 0.1 μA whichever is greater 0.02% high range
Load Regulation	0.01% low range or 0.1 μA whichever is greater 0.02% high range
Effective Output Shunt Capacitance	Less than 150 pF
Noise and Ripple (normal mode)	100 nA pk-pk max., low range 500 nA pk-pk max., high range DC to 10 kHz
Temperature Stability	Less than 0.003% / °F of setting
Time Stability	0.03% of setting for 48 hours with line, load and temperature held constant

System Specifications

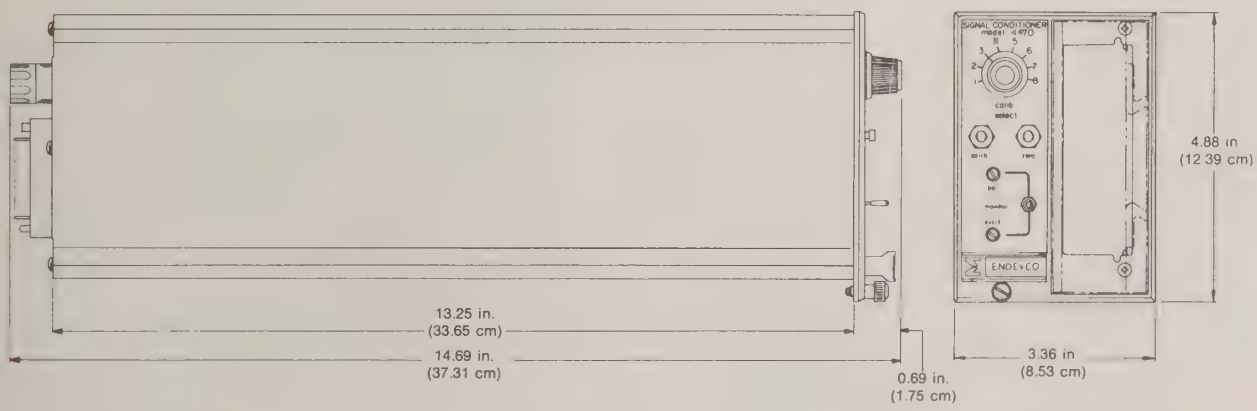
Noise to Ground	5 μV pk-pk across a grounded 350 ohm bridge
Effective Capacitance to Power Line	0.05 pF
Isolation Resistance	Greater than 100 GΩ from circuitry and chassis guard shield to primary and shield
Input Voltage	95 to 135 V rms (for 210 to 250 V rms specify 4470V) (for 90 to 110 V rms specify 4470W)
frequency	50 to 400 Hz
power	9 watts nominal at median line voltage and full load
Warmup Time	30 minutes to meet all specifications
Optional Relays	
Voltage	24 ± 4 V dc
Current	8 mA nominal for polarity and calibration step relays 15 mA nominal for zero relay

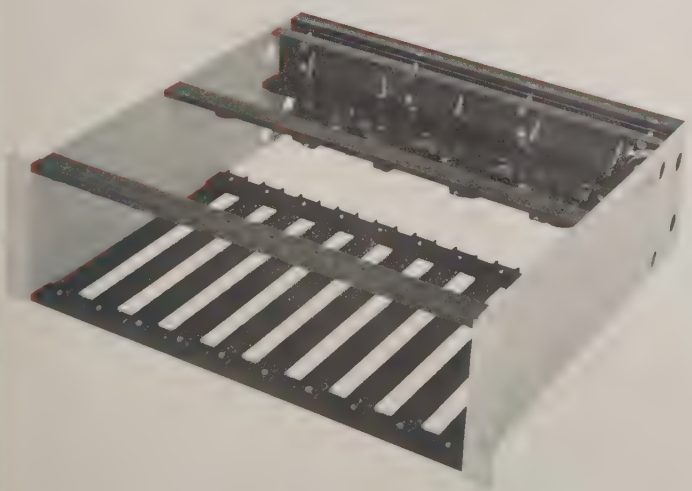
PHYSICAL CHARACTERISTICS

Size (module)		4.88 in. (12.39 cm) high x 3.36 in. (8.53 cm) wide x 13.25 in. (33.65 cm) deep (excluding connector)
Weight (nominal)	4470.000	5 lb., 14 oz. (2.7 kg)
	4470.114	6 lb., 6 oz. (3.0 kg)
	4942	12 lb. (5.5 kg)
	4943	11 lb. (5.0 kg)
Finish		Grey enamel, Federal Standard 595, No. 26595 with black trim and lettering.
Mounting		Mounts five units wide in a standard 19-inch relay rack using Model 4942 or 4943 Rack Adapters, 5¼" high — or singly in Model 2993 Carrying Case
Connectors, module		All connections to module are made through a single 34 pin, pin and socket type connector (Continental #25-34P). Mates with Burndy #MS34RM/1 or Continental 25034-16S.

ENVIRONMENTAL CHARACTERISTICS

Temperature, Operating	+15°F to +150°F (−9°C to +65°C)
Non-Operating	−65°F to +185°F (−54°C to +85°C)
Humidity	95%





MODEL 4942 RACK ADAPTER

The Model 4942 Rack Adapter accommodates up to five 4470 modules for mounting in a standard 19-inch relay rack. The adapter is fully wired for transducer, relay power, monitor and AC power connections. Each channel is provided with individually wired MS connectors for transducer leads and output.

PHYSICAL CHARACTERISTICS

TRANSDUCER CONNECTORS: MS3102A-20-27S (MS3106A-20-27P mating plug with MS3057-12 clamp supplied) with gold plated contacts.

OUTPUT CONNECTORS: MS3102A-10SL-3P (MS3106A-10SL-3S mating plug with MS3057-4 clamp supplied) with gold plated contacts.

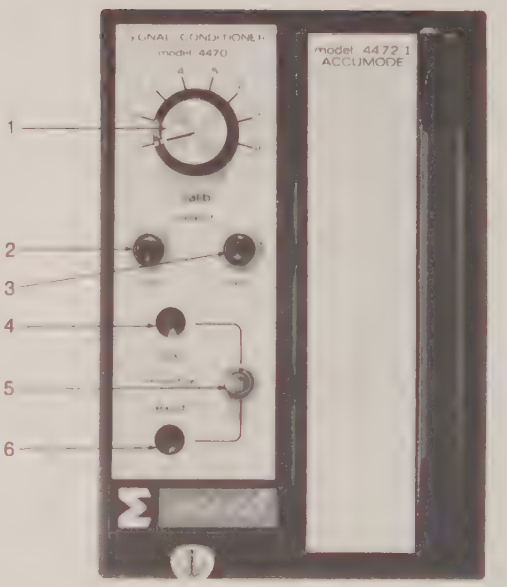
RELAY CONTROL: Barrier strip, Cinch Jones #8-140 Y.

MONITOR: Barrier strip, Cinch Jones #3-140 Y.

POWER: Integral power cord, 6-feet long with standard 3-prong line plug.

CONTROLS

1. Calibrate Selector—An eight-position rotary switch is provided for selecting calibration levels. This will generally be four points of bipolar calibration, but eight steps of one polarity are possible with some mode cards.
2. Calibrate—A momentary pushbutton switch is used to connect the selected calibration level into the circuit.
3. Zero—Local "zero" calibration is provided by this momentary pushbutton switch, which removes the excitation from the load.
4. Balance—A ten-turn 20 K ohm potentiometer is provided for adjustment of electrical zero of transducers. The control is recessed and screwdriver adjustable to minimize accidental change. Resolution is 0.02%.
5. Monitor—The monitor switch is three pole, double throw toggle type (momentary-off-momentary) which alternately connects the excitation or the data output to a monitor common circuit in the rack adapter. The guard shield is also switched to maintain a continuous, isolated shield from transducer to the monitor meter.
6. Excitation—Front panel adjustment of power supply output (when resistance programming is not being used) is provided by this recessed, screwdriver adjustable control. This potentiometer is a ten-turn, 100 K ohm unit with a resolution of 0.101%.



CALIBRATION CONTROLS

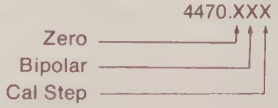
Local calibration is accomplished by use of a two-pole, eight-position rotary switch to select the desired calibration level and a DPDT pushbutton switch which connects the selected level into the circuit. To retain the exceptional versatility provided by the plug-in mode card concept, all contacts are routed to the mode card without preassignment of function.

A DPDT form D (make before break) pushbutton switch is provided for local "zero" calibration. In the constant voltage mode, this switch connects the minus excitation and minus sensing leads before opening the excitation to the load. This technique prevents momentary loss of regulation during switching and the resulting voltage transient. In the constant current mode, the zero switch shorts the output of the supply and disconnects the load.

CALIBRATION RELAYS

Provision has been made in the 4470 for installation of relays to duplicate all local calibration functions. The use of remote calibration relays enables the calibrate sequence to be initiated from a location removed from the module itself. Probably more important, however, is the ability to calibrate all channels of an installation in parallel and at a rate far faster than could be done manually. This will minimize the amount of magnetic tape or oscillograph paper required to record calibration inputs prior to a test run.

The optional relays all have bifurcated, gold-plated, crossbar contacts and are enclosed in dust covers. Diode arc suppression is provided for each relay coil. All circuitry for the calibration relays is contained on the master circuit board so that relays can be added as a simple field addition if not included in the original order. The decimal portion of the master module model number describes the relays included in the original manufacture.

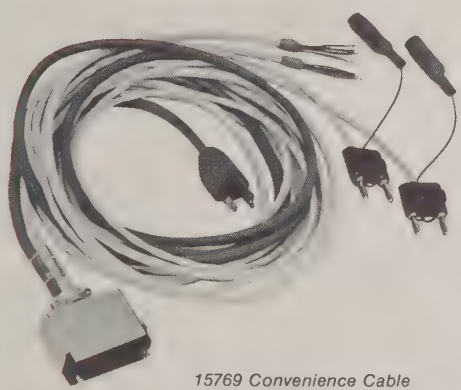


A zero in any position indicates no relay furnished, while a 1 indicates it has been provided (actual number of cal step relays is used as the last digit). A full compliment of relays would be designated by the number 4470.114, while a unit with no relays would be 4470.000.

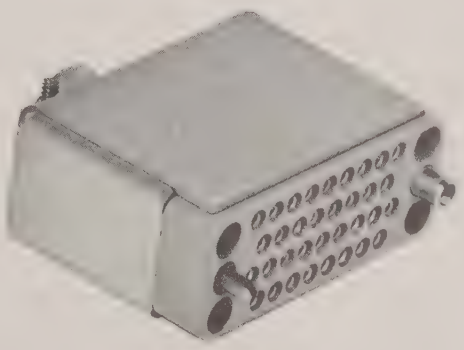
4470 SYSTEM ACCESSORIES LIST

MASTER MODULE	
4470.000	Universal Signal Conditioner
4470.114	Universal Signal Conditioner with zero calibration relay, calibration polarity relay, and four calibration step relays
PLUG-IN MODE CARDS	
4471.1A	Voltage regulated, Resistive Bridge Signal Conditioner
4475.1	Designers Card
4476.1A	Piezoresistive Accelerometer Signal Conditioner
4476.2A	Amplified Resistance Bridge Signal Conditioner
4477.2	Charge Amplifier
4478.1A	Carrier Amplifier
4479.1	Charge Converter Signal Conditioner for Model 2652
2652	Remote Charge Converter for 4479.1
MISCELLANEOUS ACCESSORIES	
4942	Rack Adapter, fully wired with individual MS connectors for transducers and outputs, five channel, mating connectors furnished, 115 volts
4815A	Transducer Simulator (used for calibrating 4477.2 card)
EP268	Module mating connector
13423	Mode card extender board
15769	Convenience cable, 115 volt
16059	Blank Panel
18306	Accessory Cable, 4815A to 4477.2, 24 in. (0.61 m)

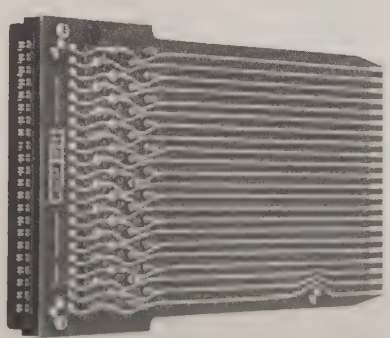
Notes:
1. Calibration or bridge completion resistors (values specified by customer) can be installed if requested at time of order.
2. For 230 volt operation, add suffix V (4470.000V, 4942V, 4943V, 15769V).
3. For 100 volt operation, add suffix W (4470.000W).
4. Other mode cards are available on special order—contact the factory.



15769 Convenience Cable



EP268 Module Mating Connector



13423 Mode Card Extender Board

MODEL 4471.1A VOLTAGE REGULATED RESISTANCE BRIDGE SIGNAL CONDITIONER

- For 1, 2 or 4 Active Elements
- For 2 to 10 Wire Systems
- Single or Double Shunt Calibration
- Excitation adjustable 1 to 30 V dc or Resistance Programmable

The Model 4471.1A Plug-in Mode Card is a voltage regulated bridge conditioner designed for use with Model 4470 Signal Conditioner Module. It is intended to condition a wide variety of transducers with active resistive elements connected in a bridge configuration.

Circuitry on the card provides for operation of the Model 4470 Power Supply in the voltage regulated mode. Bifurcated solder terminals permit easy installation of bridge completion, bridge balancing, calibration, and excitation programming resistors. Bifurcated terminal pairs are also provided for internally connecting the power supply sensing leads and for internally connecting the calibration leads.

A transducer identification strip is provided on the handle of each mode card with space for entering transducer type, serial number, sensitivity and other pertinent data for custom matching of mode card and transducer. When the customizing possibilities of this card are fully utilized, simple insertion of the card makes all the decisions necessary to: set excitation to correct value to obtain normalized full scale output; obtain zero null output; make calibration steps represent percent of full scale explicitly.

SPECIFICATIONS FOR 4470 WITH 4471.1A MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Transducers	1, 2, or 4-active arm resistive elements connected in a bridge configuration.
Wires	The card may be used with 2 to 10 wire systems.
Transducer Impedance	Limited only by rating of power supply, 100 mA dc, maximum, at 1 to 30 V dc.
OUTPUT CHARACTERISTICS	Same as transducer output, no active elements on Mode Card.
CONTROLS (on mode card)	None.
TRANSFER CHARACTERISTICS	
Balance Limiting	Terminals are provided for installation of balance limiting resistors.
Resistance Programming	Terminals are provided for installation of a 3200 Ω/V resistor for fixed output excitation level.
Bridge Completion	Four pairs of terminals are provided for installation of bridge completion resistors.
External Sensing	Circuit normally connected for internal sensing. When sense leads are connected to external load, remove links.
CALIBRATION (Resistors R1 through R8)	Terminals are provided for installation of up to eight resistors to provide four step bipolar double shunt calibration.
Internal Connections	Terminals are provided to internally connect the calibration leads if separate calibration wires are not desired.

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
RESISTORS	Terminals are spaced to accept axial lead resistors having maximum envelope dimensions of ¼" diameter by 13/16" long.
WEIGHT	100 grams (3.5 oz.) maximum, without resistors.

MODEL 4475.1 DESIGNER'S CARD

You provide the transducer interface, the 4470 provides:

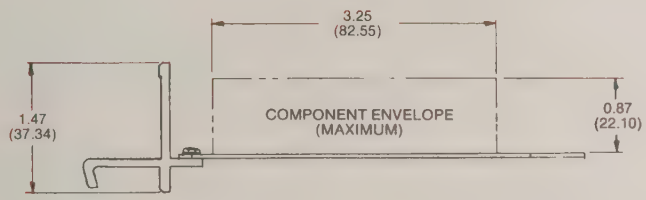
- A highly isolated, highly regulated power source
- A well shielded enclosure
- A convenient packaging system
- Calibration and monitoring circuitry
- Routing of data outputs through normal data systems connections

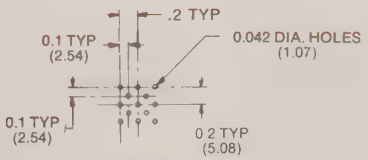
The Model 4475.1 Plug-in Mode Card is designed for prototyping or "one shot" custom design of conditioning circuitry not provided in the standard series. All 44 access points to the master module are made available at the gold-plated contacts on the connector edge of the card. The circuit board is perforated overall on a standard 0.1-inch spacing for direct insertion of components or for insertion of the Vector #T 42-1 pins (100 furnished with card).

The power supply of the 4470 can be operated in either a constant voltage or a constant current mode by making the appropriate circuit connections on the mode card. Output may be continuously adjustable by means of the master module excitation adjust, or fixed by means of an excitation programming resistor.

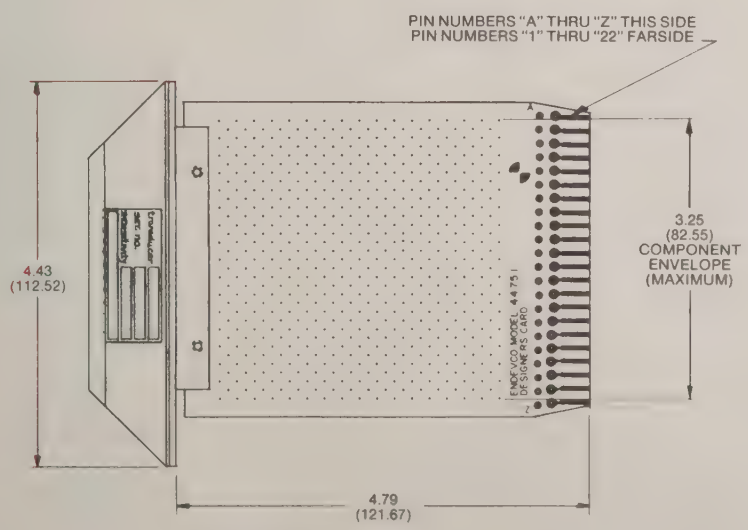
The front panel of the 4475.1 can be drilled for installation of controls or connectors (so long as the maximum component envelope is not exceeded) and electrical access to the transducer can be either front panel or through the normal rack connectors. Thus, virtually any transducer can be accommodated, and all circuitry enjoys the ideal environment of a well shielded and isolated enclosure.

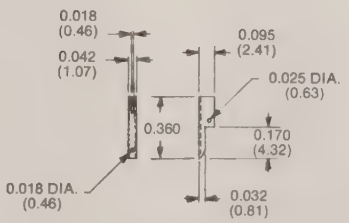
A transducer identification strip is provided on the mode card handle with space for entering transducer type, serial number, sensitivity, and other pertinent data.





TYPICAL
HOLE PATTERN





PIN DETAIL
(VECTOR #T42-1)

DIMENSIONS IN INCHES
(MILLIMETERS)

TOLERANCES
.XX = +.03 (+0.8 mm)
XXX = +0.10 (+0.25 mm)

MODEL 4476.1A CONDITIONER FOR PIEZORESISTIVE ACCELEROMETERS

- Differential Input
- Standardized, Full Scale Output of ±2.5 Volts.
- Full Scale Output for 20%, 40%, 60%, 80% or 100% of Accelerometer Range
- For Piezoresistive Accelerometers with Full Range Output of 80 to 1080 mV

The Model 4476.1A Plug-in Mode Card is a Piezoresistive Accelerometer Conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended to condition piezoresistive accelerometers, connected in a bridge configuration, with a full range output of 80 to 1080 mV, and requiring amplification.

Circuitry on the card provides for dialing in the full range output of the transducer, and amplification of signal to obtain a standardized full scale output of 2.5 volts. Transducer excitation voltage, bridge balancing, and voltage substitution calibration is also provided. Bifurcated solder terminals permit easy installation of bridge completion resistors.

A transducer identification strip is provided on the handle of each mode card with space for entering transducer type, serial number, sensitivity, and other pertinent data for custom matching of mode card and transducer. A replaceable range identification label is supplied with each 2260 Series Accelerometer shipped by Endevco. When inserted in the 4476.1A Front Panel, the range switch is converted to read directly in full scale g's.

SPECIFICATIONS FOR 4470 with 4476.1A MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS

Transducers	2 or 4 active arm resistive elements connected in a bridge configuration.
Input Connection	Differential
Input Impedance	1 megohm, minimum
Source Resistance	2000 ohms, maximum
Overload Recovery Time	50 microseconds
Common Mode Rejection	80 dB minimum at 60 Hz 70 dB minimum at 1000 Hz
Common Mode Voltage	5 V pk, maximum

OUTPUT CHARACTERISTICS

Output Connection	Single ended
Output Voltage Full Scale	±2.5 volts pk
Overvoltage	±7.5 volts pk, nominal
Linear Output Current	±10 mA pk, maximum
Output Impedance	Less than 20 ohms
Noise and Ripple	2 mV rms, maximum
Capacitive Load Effect	Stable to 10μF
Zero Stability and Temperature Coefficient	0.2% of F.S. for 24 hours plus 0.02%/°F.

TRANSDUCER EXCITATION REGULATOR

Output Voltage	Adjustable 9.5 to 10.5 V dc. Factory set at 10 ±0.02 V dc with 500 ohm load.
Output Current	0 to 50 mA dc
Short Circuit Protection	Circuit will not be damaged due to short circuit at output.
Line and Load Regulation	Less than 0.2% change for line voltage change 95 to 135V ac and load change 2000 to 300 ohms.
Temperature Stability	Less than 0.003%/°F over temperature range +15°F to +150°F.
Time Stability	Less than 0.03% for 48 hours with constant line, load and temperature.

TRANSFER CHARACTERISTICS

Gain Ranges (Switch S1 and Potentiometer R17)	
For accelerometers having Full Range Output of 80 to 1080 mV:	Full Scale Output for 20%, 40%, 60%, 80% or 100% of Full Range Acceleration.
Accuracy	±1.5% of full scale
Frequency Response	±5%, dc to 20,000 Hz
Gain Stability	Less than ±0.1% for 24 hours plus ±0.005%/°F.
DC Linearity	Less than ±2.5 mV from best fit straight line through zero.

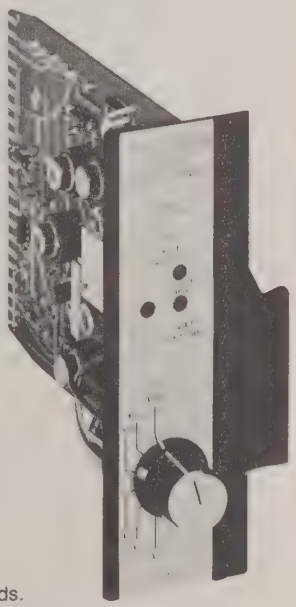
BRIDGE COMPLETION	Terminals provided for two completion resistors.
BALANCE LIMITING	40.2 k Ω resistor provided.
CALIBRATION	Resistors are provided for four steps of bipolar voltage substitution calibration (±1%). Amplifier output disconnected during calibration.

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
CONTROLS (on Mode Card)	
Full Scale mV	Ten turn potentiometer which calibrates system for specific accelerometer full scale output.
Range	Five position switch which selects percentage of accelerometer output for full scale amplifier output. With Slide-in Label: selects full scale acceleration in g.
WEIGHT	200 grams (7 oz.) max.

MODEL 4476.2A AMPLIFIED RESISTANCE BRIDGE SIGNAL CONDITIONER

- Differential Input
- For 1, 2, or 4 Active Elements
- For 2 to 9 Wire Systems
- Frequency Response DC to 10,000 Hz
- Bipolar Single Shunt Calibration
- Excitation is Adjustable or Resistance Programmable 0 to 15 V dc
- Output ±5 volts peak



The Model 4476.2A Plug-in Mode Card is a voltage regulated bridge conditioner and differential amplifier designed for use with the Model 4470 Signal Conditioner Module. It is intended to condition a wide variation of transducers with active resistive elements connected in a bridge configuration.

Circuitry on the card provides for excitation of the transducer in a voltage regulated mode, and amplification of the transducer output signal. Bifurcated solder terminals permit easy installation of bridge completion, calibration, and excitation programming resistors. Bifurcated terminal pairs are also provided for internally connecting the excitation sensing leads and calibration leads.

A programming resistor or potentiometer on the mode card sets the transducer excitation to a convenient value.

Terminals are provided for the addition of capacitors which establish a low pass interstage active filter with a terminal slope approaching —6, —12, or —18 dB/octave.

SPECIFICATIONS FOR 4470 with 4476.2A MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Transducers	1, 2, or 4 active-arm resistive elements connected in a bridge configuration.
Input Connection	Differential
Input Impedance	100 megohm, minimum.
Input Bias Current	500 nA maximum.
Source Resistance	4000 Ohms, maximum.
Common Mode Voltage	±5.0 volts, peak, maximum.
OUTPUT CHARACTERISTICS	
Output Connection	Single ended.
Linear Output Voltage	±5.0 volts pk, minimum.
Overvoltage	±7.5 volts pk, nominal.
Linear Output Current, normal	±20 mA pk, minimum.
limited at	±50 mA pk, nominal.
Output Impedance	1 Ohm, maximum.
Noise and Ripple, wideband	0.5 mV rms, RTO, maximum. 10μV rms, RTI, maximum.
Capacitive Load Effect	Stable to 10 μF.
Amplifier Zero	Adjustable ±5 mV, RTI.
Zero Stability	<0.01% Full Scale plus 40 μV RTI, for 24 hours.
Zero Temperature Stability	<0.005% of F.S./°F plus 10 μV/°F, RTI.
Short Circuit Protection	Current limiting protects amplifier against short circuit.

TRANSFER CHARACTERISTICS	
Gain Steps	1, 3, 10, 30, 100, 300
Gain Vernier	1.0 to >3.5, continuous.
Gain Step Accuracy	±1.5%
Gain Stability	<0.01% for 24 hours plus 0.003%/°F.
Frequency Response	±5%, dc to 10,000 Hz. <3db down at 20,000 Hz. Terminals provided for optional capacitors to obtain high frequency rolloff.
DC Linearity	<±2.5 mV deviation from best fit straight line from Zero over a ±5V output range.
Common Mode Rejection	>80 dB at unity gain.
(at 60 Hz, 1 k Ω unbalance)	>100 dB at gains over 100.
Overload Recovery Time	20 μsec.
EXCITATION REGULATOR	
Output Voltage	Adjustable or programmable 100 mV to 15 V dc. Factory Set at 10.0 V dc ±1%.
Output Current	50 mA maximum or 400 mW bridge dissipation.
Line and Load Regulation	Less than 0.015% change for line voltage change 95 to 135 V ac, or load change 0 to 50 mA.
Noise and Ripple	<25 μV rms, dc to 20,000 Hz.
Temperature Stability	<0.005%/°F or 10 μV/°F whichever is larger.
Time Stability	0.05% maximum for 48 hours.
Short Circuit Protection	Regulator will not be damaged by short circuit at output.
TRANSDUCER CONDITIONING	
Bridge Completion	Terminals provided for three completion resistors.
Balance Limiting	40.2 k ohm resistor provided.
CALIBRATION	Terminals are provided for installation of up to four resistors to provide four step bipolar single shunt calibration.
Internal Connections	Three terminal pairs and links are provided to internally connect the calibration leads when external calibration wires are not desired.
EXTERNAL SENSING	Two terminal pairs and links are provided to internally connect sense leads when external sense wires are not desired.
CONTROLS (on mode card)	
Gain	Six-position rotary switch.
Excitation Zero	Push-button switch reduces excitation to less than ±2 mV.
Amplifier Zero	Screwdriver adjustable potentiometer nulls amplifier dc offset.
Gain Vernier	15 turn potentiometer adjusts amplifier gain 1.0 to 3.5.
Excitation Adjust	15 turn potentiometer or programming resistor.

PHYSICAL

MODE CARD	Designed for plugging into front panel of 4470 Module.
RESISTORS	Bifurcated solder terminals are spaced to accept axial lead resistors having maximum envelope dimensions of ¼″ diameter by ⅜″ long.
WEIGHT	190 grams (6.8 oz.) maximum without calibration resistors.

MODEL 4477.2 CHARGE AMPLIFIER

- Full Scale Ranges from 1 to 300 g for Transducer Sensitivities of 5 to 55 pC/g.
- Useable with long input cables, up to 100,000 pF.
- System Sensitivity independent of input cable length
- Flat Frequency Response, ±5%, 2 to 20,000 Hz.
- Complete channel to channel isolation.
- Integral and isolated power supply
- Calibrated Sensitivity Dial

The Model 4477.2 Plug-in Mode Card is a charge amplifier designed for use with the Model 4470 Signal Conditioner Module. It is intended for use with piezoelectric or capacitive transducers.

The plug-in card contains a charge converter and a voltage amplifier with adjustable gain. The gain characteristics are such that the output voltage is proportional to the charge generated by the input transducer. With this characteristic, the transducer output and temperature response are independent of the cable length between the transducer and amplifier.

The isolated power supply in the Model 4470 allows multichannel operation with complete channel-to-channel isolation to prevent ground loops. A calibrated dial is provided to set in transducer sensitivity. Full scale output of ±2.5 volts peak is obtained for input measurands of 1, 3, 10, 30, 100 or 300 g, psi, or lbs.

SPECIFICATIONS FOR 4470 WITH 4477.2 MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Input Connection	Single ended
Source Impedance[1]	Capacitive devices only. Shunt resistive 50 MΩ, min.
Source Capacitance[1]	10,000 pF max., lowest four ranges. 100,000 pF max., upper two ranges.
Overload Recovery Time	Unit does not overload for up to three times full scale input. For 1 ms square pulse 10 times full scale input, amplifier recovers within 100 μs.
OUTPUT CHARACTERISTICS	
Output Connection	Single ended
Output Voltage	
Full scale:	±2.5 volts peak
Overvoltage:	±7.5 volts peak, nominal
Linear Output Current	±2.5 mA peak, maximum.
Output Impedance	2 Ohms, maximum.
Residual Noise	Less than the total of 0.007 pC rms plus 0.0025 pC rms per 1000 pF of source capacitance referred to input, plus 250 μV rms referred to output.
TRANSFER CHARACTERISTICS	
Gain Ranges, Full Scale for Sensitivities:	
.5 to 5.5 pC/g	10, 30, 100, 300, 1000, 3000 g
5.0 to 55 pC/g	1, 3, 10, 30, 100, 300 g
Actual Gain	0.15 to 500 mV/pC
System Accuracy	±1.5% of F.S., any range, source capacitance of 3500 pF or less, at +75°F (+24°C).
Gain Stability	Better than 0.3% per 1000 pF source capacitance on lower four full scale ranges. Better than 0.5% per 10,000 pF source capacitance on upper two full scale ranges. Better than +1% with time and temperature.
Frequency Response	±5%, 2 Hz to 20,000 Hz
Linearity	±0.5% of reading from best straight line approximation to curve of output amplitude versus input amplitude.
Total Harmonic Distortion	0.2% maximum
CALIBRATION	Provision for external calibration signal applied at phone jack on front panel through 1000 pF ±1% capacitor.
WARMUP TIME[1]	1 minute
POWER	+30 volts dc from 4470 set by program resistor, R12, on mode card.

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
CONNECTORS (on Mode Card)	
Input	Coaxial, 10-32 thread, Microdot S-50 Series or equivalent.
Calibration	Phone Jack — Mating Plug Switchcraft No. 780 not supplied.
CONTROLS (on Mode Card)	
Sensitivity	Five turn potentiometer, with calibrated turns dial.
Full Scale	Six position rotary switch.
GROUND	Signal ground is isolated from each other channel and rack enclosure.
WEIGHT	240 grams (8.5 oz.) maximum.
ACCESSORY AVAILABLE	Model 18036 Cable

NOTE

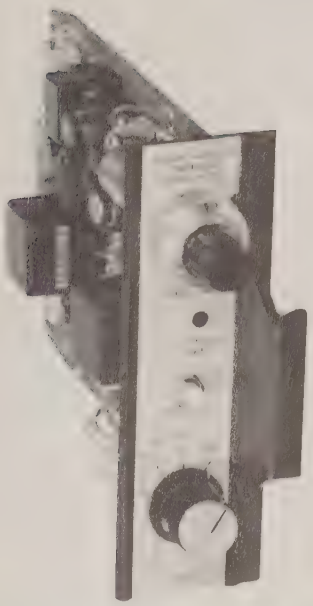
[1]To meet all specifications.

MODEL 4478.1A CARRIER AMPLIFIER

- Carrier Voltage 1 V rms at 3000 Hz.
- 6 Selectable Gain Ranges
- Vernier Gain Adjustment
- Synchronous Demodulator
- Bias for balance or offset of output
- Adjustable bipolar calibration.

The Model 4478.1A Plug-in Mode Card is carrier amplifier and demodulator designed for use with the Model 4470 Signal Conditioning Module. It is intended to provide carrier excitation to, and demodulate the signal from, linear variable differential transformers and variable reluctance type transducers.

Circuitry on the card provides ac excitation voltage, amplification, synchronous demodulation, filtering, offset and calibration voltages. Six gain step ranges plus a vernier adjustment allows selection of gain from less than one to 100. Output bias (offset) is adjustable by means of Balance potentiometer R28 on the 4470 Module. A turns counting dial on the calibration potentiometer provides accurate setting of calibration signal, with a span equal to the carrier amplitude.



SPECIFICATIONS FOR 4470 WITH 4478.1A MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

CARRIER EXCITATION	
Voltage	1 V rms ±2% (open circuit)
Output Current	2 mA rms, maximum
Frequency	3000 Hz ±5%
Distortion	2% maximum
Output Impedance	60 Ohms nominal
INPUT CHARACTERISTICS	
Input Connection	Single ended
Input Impedance	1 M Ω minimum
Source Impedance	10 k Ω maximum
OUTPUT CHARACTERISTICS	
Output Connection	Single ended
Linear Output Voltage	±2.5 V peak, full scale
Overvoltage	±5 V peak, nominal
Linear Output Current	±2.5 mA peak
Ripple and Noise	5 mV rms max., at maximum output. 2 mV rms max., at null.
Output Impedance	1 ohm maximum
Stability[1]	±1% of full scale for 24 hours ±0.1%/°F
Output Bias	±2.5 V dc, minimum
TRANSFER CHARACTERISTICS	
Gain Ranges	2, 5, 10, 20, 50, 100
Vernier Gain	< 0.4 to > 1.0, continuous
Gain Step Accuracy	±2%
Linearity	±0.25% of full scale
Frequency Response	dc to —3 db at 300 ±30 Hz
CALIBRATION	Output bias control is also disconnected during calibration. During calibration, transducer input is disconnected and the wiper arm of a potentiometer connected in its place.
GROUND	Signal ground is isolated from each other channel and rack enclosure.
WARMUP TIME	20 minutes.

PHYSICAL

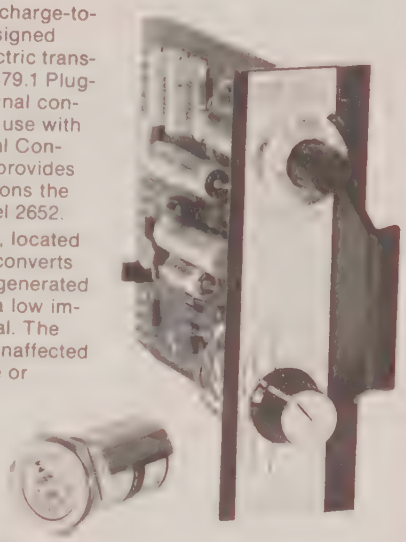
MODE CARD	Designed for plugging into front panel of Model 4470 Module.
CONTROLS (on Mode Card)	
Calibrate	Ten turn potentiometer, with turns counting dial.
Vernier Gain	Screwdriver adjustable single turn potentiometer.
Gain	Six position rotary switch.
Amplifier Zero	Pushbutton switch disconnects transducer and connects amplifier input to circuit ground.
WEIGHT	225 grams (8 oz.) max.

NOTE

[1]Stability includes the combined effects of changes at the output due to changes in carrier excitation, amplifier gain, amplifier zero and output bias voltage.

MODEL 4479.1/2652 REMOTE CHARGE CONVERTER SIGNAL CONDITIONER

The Model 2652 is a charge-to-voltage converter designed for use with piezoelectric transducers. The Model 4479.1 Plug-in Mode Card is a signal conditioner designed for use with the Model 4470 Signal Conditioner Module and provides power to, and conditions the signal from, the Model 2652.



The charge converter, located near the transducer, converts the electrical charge generated by the transducer to a low impedance voltage signal. The output is essentially unaffected by the length of cable or changes in cable capacitance between transducer and driver. Only a single coaxial cable or shielded, twisted pair is required between the 2652 Converter and the 4479.1.

Circuitry on the plug-in card provides a constant current for the converter, a voltage amplifier, and a range switch. A calibrated dial is also provided to set in transducer sensitivity. Full scale output ±2.5 volts peak is obtained for input measurands of 0.1, 0.3, 1.0, 3, 10, and 30 g, psi, or lbs.

SPECIFICATIONS FOR 4470 with 4479.1 MODE CARD and 2652 CHARGE CONVERTER

(Also see Specifications for 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS (2652)

Input Connection	Single Ended
Source Impedance	Capacitive devices only. Shunt resistance 25 MΩ minimum.
Source Capacitance	10,000 pF, maximum

OUTPUT CHARACTERISTICS (2652)

Output Connection	Single Ended
Output Impedance	5 ohms nominal, when used with 4479.1
Maximum Capacitance between 2652 and 4479.1	To meet all specifications, C = K/f μF, where f is maximum frequency of interest and K = 330,000 for 1 pC full scale, K = 3,000 for 100 pC full scale, K = 85 for 3000 pC full scale. Worst case: 8500 pF maximum at 10,000 Hz and 3000 pC pk input signal.

INPUT CHARACTERISTICS (4479.1 Card)

Input Connection	Single Ended
Input Resistance	1000 ohms in series with 390 μF

OUTPUT CHARACTERISTICS (4479.1 Card)

Output Connection	Single Ended
Linear Output Voltage	±2.5 V pk, Full Scale
Linear Output Current	±2.5 mA pk, maximum
Output Impedance	50 ohms, maximum, in series with 200 μF
POWER	+30 V dc from 4470 set by program resistor on mode card.
GROUND	Signal ground is isolated from each other channel and rack enclosure.

TRANSFER CHARACTERISTICS (2652 and 4479.1)

Full Scale Ranges for Sensitivities:	
1 to 10 pC/g (not shown)	1, 3, 10, 30, 100, 300 g
10 to 100 pC/g	0.1, 0.3, 1, 3, 10, 30 g
Actual Gain	0.8 to 2500 mV/pC
System Accuracy	±3% of F.S., any range, at +24°C (+75°F) and source capacitance of 1000 pF, maximum.
Gain Stability	Better than 0.5% per 1000 pF source capacitance. Better than 2%, −10°C to +65°C. (+15°F to +150°F). Gain decreases approximately 1% for every 10 ohms of cable resistance.
Frequency Response	+5%, 3 Hz to 10,000 Hz
Linearity	±0.5% of reading from best straight line.
Total Harmonic Distortion	0.2%, maximum
Residual Noise	Less than the total of 0.0075 pC rms plus 0.0025 pC rms per 1000 pF source capacitance referred to input plus 0.5 mV rms referred to output.

PHYSICAL

MODE CARD (4479.1)	Designed for plugging into front panel of 4470 Module.
CONNECTORS (2652)	
Input	Coaxial, 10-32 thread, Microdot S-50 Series or equivalent.
Output	Solder terminals.
MOUNTING (2652)	Converter mounts in 13/16" hole. Washer and 13/16" x 28" nut supplied.
CONTROLS (on Mode Card)	
Sensitivity	Ten turn potentiometer, with calibrated turns dial.
Full Scale	Six position rotary switch.
WEIGHT	
Mode Card	180 grams (6.5 oz) maximum
Charge Converter	65 grams (2.3 oz)

ENVIRONMENTAL

OPERATING TEMPERATURE (2652)	−54°C to +85°C (−65°F to +185°F)

RELIABILITY: Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures together with conservative specifications, have made the name Endevco synonymous with reliability.

Continued product improvement necessitates that Endevco reserve the right to change these specifications and/or prices without notice.

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ELECTRICAL PARTS LIST

Model 4476.2A
Amplified Bridge Conditioner
Mode Card

Des. No.	Part	Value and Description	Manufacturer & No.	Endevco Part No.
C1	Capacitor	.0012 µF, ±5%, 200 V, Mylar	Sprague 192P12252	EC906
C2	Capacitor	Selected (Optional)		
C3	Capacitor	.0033 µF, ±10%, 200 V, Mylar	Sprague 192P33292	EC164
C4	Capacitor	Selected (Optional)		
C5	Capacitor	Selected (Optional)		
C6	Capacitor	150 pF, ±5%, 500 V, Mica	Elmenco DM15-151J	EC432
C7	Capacitor	.01 µF, ±20%, 50 V, Ceramic	Sprague 19C214A6	EC115
C8	Capacitor	.01 µF, ±20%, 50 V, Ceramic	Sprague 19C214A6	EC115
C9	Capacitor	4.7 µF, ±20%, 25 V, Tantalum	Kemet K4R7W25	EC665
C10	Capacitor	4.7 µF, ±20%, 25 V, Tantalum	Kemet K4R7W25	EC665
C11	Capacitor	4.7 µF, ±20%, 25 V, Tantalum	Kemet K4R7W25	EC665
C12	Capacitor	20 pF, ±0.5 pF, 500 V, Mica	Elmenco DM15-200J	EC12
Q1	Transistor	2N3904		EQ130
Q2	Transistor	2N3906		EQ127
Q3	Transistor	2N3904		EQ130
Q4	Transistor	2N3906		EQ127
Q5	Transistor	2N3904		EQ130
Q6	Transitor	2N3906		EQ127
R1	Resistor	Selected (Optional)		
R2	Resistor	Selected (Optional)		
R3	Resistor	Selected (Optional)		
R4	Resistor	Selected (Optional)		
R5	Resistor	1.74 k, ±0.5%, 1/10 W, M.F.	RN55C	ER1858
R6	Resistor	2.222 k, ±0.5%, 1/10 W, M.F.	RN55C	ER2257
R7	Resistor	4.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER1764
R8	Potentiometer	20 k, ±10%, 3/4 W,	Beckman 78L	ER2329
R9	Resistor	10.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER802
R10	Resistor	10.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER802
R11	Resistor	10.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER802
R12	Resistor	10.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER802
R13	Potentiometer	1 k, ±10%, 1/2 W	Bourns 3299W-1-102	ER2827
R14	Potentiometer	1 k, ±10%, 1/2 W	Bourns 3299W-1-102	ER2827
R15	Resistor	Selected (Optional)		

Des. No.	Part	Value and Description	Manufacturer & No.	Endevco Part No.
R16	Resistor	Selected (Optional)		
R17	Resistor	Selected (Optional)		
R18	Resistor	3.16 k, ±1%, 1/10 W, M.F.	RN55C	ER1772
R19	Resistor	3.16 k, ±1%, 1/10 W, M.F.	RN55C	ER1772
R20	Resistor	3.48 k, ±1%, 1/10 W, M.F.	RN55C	ER1686
R21	Resistor	37.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER1803
R22	Resistor	4.111 k, ±0.5%, 1/10 W, M.F.	RN55C	ER2258
R23	Resistor	37.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER1803
R24	Potentiometer	10 k, ±10%, 1/2 W, Cermet	Beckman 62P	ER2236
R25	Resistor	3.32 k, ±1%, 1/8 W, M.F.	RN60C	ER1965
R26	Potentiometer	10 k, ±10%, 3/4 W, Cermet	Beckman 77P	ER1723
R27	Resistor	3.32 k, ±1%, 1/8 W, M.F.	RN60C	ER1965
R28	Resistor	1.70 k, ±0.5%, 1/10 W, M.F.	RN55C	ER1063
R29	Resistor	976Ω, ±0.5%, 1/10 W, M.F.	RN55C	ER1579
R30	Resistor	2.2 k, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER517
R31	Potentiometer	10 k, ±10%, 1/2 W, Cermet	Beckman 62P	ER2236
R32	Resistor	6.81 k, ±1%, 1/10 W, M.F.	RN55C	ER1710
R33	Resistor	10 k, ±1%, 1/10 W, M.F.	RN55C	ER1550
R34	Resistor	10 k, ±1%, 1/10 W, M.F.	RN55C	ER1550
R35	Resistor	10 k, ±1%, 1/10 W, M.F.	RN55C	ER1550
R36	Resistor	15 k, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER512
R37	Resistor	10 M, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER510
R38	Potentiometer	20 k, ±10%, 1/2 W, Cermet	Beckman 62P	ER2232
R39	Resistor	5.1 M, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER2785
R40	Resistor	220Ω, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER260
R41	Resistor	200Ω, ±5%, 1/2 W, Comp.	A. Bradley Type EB	ER165
R42	Resistor	200Ω, ±5%, 1/2 W, Comp.	A. Bradley Type EB	ER165
R43	Resistor	200Ω, ±5%, 1/2 W, Comp.	A. Bradley Type EB	ER165
R44	Resistor	200Ω, ±5%, 1/2 W, Comp.	A. Bradley Type EB	ER165
R45	Resistor	220Ω, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER260
R46	Resistor	6.8 k, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER203
R47	Resistor	3.16 k, ±1%, 1/10 W, M.F.	RN55C	ER1772
R48	Resistor	3.16 k, ±1%, 1/10 W, M.F.	RN55C	ER1772
R49	Resistor	6.8 k, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER203
R50	Resistor	91Ω, ±5%, 1/2 W, Comp.	A. Bradley Type EB	ER1111

Des. No.	Part	Value and Description	Manufacturer & No.	Endevco Part No.
R51	Resistor	91Ω, ±5%, 1/2 W, Comp.	A. Bradley Type EB	ER1111
R52	Resistor	3.3 k, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER866
R53	Resistor	3.3 k, ±5%, 1/4 W, Comp.	A. Bradley Type CB	ER866
R54	Resistor	3.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER923
R55	Resistor	3.0 k, ±0.5%, 1/10 W, M.F.	RN55C	ER923
R56	Potentiometer	20 k, ±10%, 3/4 W, Cermet	Beckman 77P	ER1788
R57	Resistor	Selected (Optional)		
R58	Resistor	40.2 k, ±1%, 1/10 W, M.F.	RN55C	ER2451
R59	Resistor	76.8 k, ±1%, 1/10 W, M.F.	RN55C	ER3092
S1	Switch	(Gain)		16487
S2	Switch	Pushbutton (Excite Zero)	C & K P8121	ES109
Z1	Int. Ckt.	Selected (Red & Yel Dots)		16796-1
Z2	Int. Ckt.	Selected (Red & Yel Dots)		16796-1
Z3	Int. Ckt.	LM741CN	Nat'l Semi-Cond.	EQ251
Z4	Int. Ckt.	LM741CN	Nat'l Semi-Cond.	EQ251
Z5	Int. Ckt.	LM301AN	Nat'l Semi-Cond.	EQ273
Z6	Int. Ckt.	HA2-911-5	Harris Semi-Cond.	EQ214
Z7	Int. Ckt.	LM741CN	Nat'l Semi-Cond.	EQ251
Z8	Int. Ckt.	LM741CN	Nat'l Semi-Cond.	EQ251

WARRANTY

Endevco Dynamic Instrument Division, A Division of Becton, Dickinson and Company, warrants each new electronic instrument to be free from defects in material and workmanship for one year from date of shipment to the original purchaser. This warranty does not extend to units that have been misused or used in violation of Endevco recommendations, or to units that have been altered or repaired outside Endevco's factory. Defects covered by this warranty will be remedied at no charge, provided this instrument is delivered to the factory with all transportation charges prepaid. If, upon examination, it is found that the defect is not within the scope of this warranty, a statement of repair charges and a request for authorization to proceed with repair will be submitted.

The above warranty period does not extend to new cable assemblies, mounting accessories, connectors and other non-serialized products which are only warranted to meet applicable Endevco specifications when shipped from our factory.

The liability of Endevco under this warranty is limited to repair or replacement of any defective instrument within the sole discretion of Endevco. The foregoing warranty is exclusive and in lieu of all other warranties expressed or implied.

Robert F. Martin

Manager
Quality/Reliability Control

President

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